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THE ENGINEER

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AN INADEQUATE ROADS BILL

On Thursday of last week, the Road Traffic Bill received its third reading in the House of Commons. Though the Lords may look rather askance at it, for some time ago they passed a Bill through their House with parallel but somewhat different objects only to see it dropped in favour of the present Bill, it will now very probably emerge as an Act without substantial change. In fact, despite its rather imposing title, the Bill is really a thing of little account. Its main purpose is to authorise the carrying out of what amounts to two experiments.

One of those experiments relates to the use of parking meters in large cities and we shall make no further reference to it beyond expressing very much doubt whether it will have any effect whatever in easing traffic flow in city streets. Only the expenditure of public money in driving really modern highways right into the centres of cities and the provision of really adequate off-street parking can solve that problem ; tinkering with it, as in this Bill, will prove quite ineffective. The other experiment is that of enforcing tests for roadworthiness on vehicles more than ten years old. In principle no rational opposition can be expressed to such a proposal. But in the putting of the proposal into practice we foresee the emergence of considerable difficulties, and we doubt whether very much effect in reducing accidents can be expected from it. The point is, of course, that one cannot divorce a vehicle from its driver. Many a ten-year-old car is being driven about to-day with brakes and steering that a testing station would regard as defective. Yet they are driven just as safely as new cars in perfect condition. Whether, in fact, a somewhat defective car is driven safely or not depends, just as the safe driving of a new car in perfect condition depends, on the judgment of the driver about the speed in any given circumstances at which the car can be safely driven. The argument applies to almost, though not absolutely all, defects unless they are so gross that it is dangerous for the vehicle to roll along at all. Yet how can the personnel of a testing station possibly bear that relationship in mind ? Hence, a vehicle whose turn indicators are out of order will continue to be regarded as unroadworthy even though by opening the side window and making hand signals the driver can drive rather more safely than before ! And an old car incapable of more than 40 m.p.h. may be consigned to the scrap-heap, owing to the cost of bringing its brake gear up to standard, when, in fact, as used by its driver, the distance in which it will pull up is far less than that of a modern car driven habitually at 60 m.p.h.! Unless, therefore, those who undertake the testing take a less severe view of defects than have the testing stations at Slough and Hendon, great dissatisfaction is going to be created and many older vehicles fully capable of being safely driven and providing cheap motoring for the less pecunious will be sent to the scrap-heap. The effect in improving safety on the roads is likely to be slight.

What is to be feared is that by passing this Bill into law the Government will believe that it has made a really satisfactory contribution to traffic flow in cities and to safety on the roads. In fact, neither legislation nor propaganda can now have much effect. Only expenditure upon improved roads can bring about a

change. We agree, of course, with Mr. Watkinson, who said in the debate that more and better roads cannot be regarded as a "universal panacea" for accidents. Accidents do occur on motorways. But there is plenty of evidence that the better the roads are the fewer the accidents that occur. That evidence is very direct where, for example, a minor road improvement has removed a defect in the layout or where a new by-pass, properly planned, has drawn traffic away from a heavily congested neighbourhood. Propaganda about road safety has been with us for twenty years or more. More and more restrictions have been laid on road users. Yet there are still 5000 deaths every year and as the numbers of vehicles increase so do the numbers of accidents. For inevitably human beings are frail. Their concentration cannot at all times be absolute, their judgment always perfect. The quickest and most effective way to reduce accidents, as highway engineers well know, is not to tinker as this Bill does, not to raise penalties as this Bill raises them, not to add yet further restrictions, but to build new roads that make less extreme demands upon the emotional restraint, judgment and concentration of drivers and other road users, and to build those roads within cities as well as between them. The difficulty of convincing Governments that a really vigorous road-building policy is essential astonishes us. For it is not a matter only of safety—though it is very surprising that whereas every possible aid to safety is insisted upon in the operation of air, sea and rail transport, the construction of safer roads is not also insisted upon. It is an urgent matter of economics as well. The fuel and power industries, the iron and steel industry, and the railways are all recognised to be of such basic importance to the economy of the country that they are encouraged, rather than discouraged, when they indulge in immense capital expenditure on the improvement of their plant. But is not road transport as basically important to this country's well-being ? Were there in existence to-day a Roads Authority as independent of the Treasury as the Central Electricity Authority or the Iron and Steel Board, we find it very difficult to believe that there would not to-day be in course of urgent prosecution a very full programme of road construction up and down the country.

OPEN DAYS AT HARWELL

How remarkably the Conference on the Peaceful Uses of Atomic Energy held at Geneva last August has influenced the official attitude towards nuclear research ! Before that conference almost all was shrouded in secrecy. Since it was held, the veils concealing activities of many kinds have steadily been lifted. One example of the effect was the holding all last week by the Atomic Energy Research Establishment at Harwell of "Open Days" to which were invited not only distinguished visitors, university professors and industrialists and engineers active in the nuclear field, but the technical Press and even the lay Press as well ! Unprecedentedly, Britain's most secret research establishment was laid open to the view of almost anyone who cared to ask for an invitation. Fortunately, perhaps—for even we, biased, possibly, against secrecy, admit that some of the work being done at Harwell is better concealed from the public gaze in the interests of national security—it is not really difficult to control the activities of visitors. Anyone knowing that strongly radioactive material may be around feels chary of attempting to by-pass a notice that bars access by visitors to certain places.

Of course, during a visit confined to a few hours in a single day and under the direction of a single guide for several people, it is not really possible to learn very much. In an article on another page of this issue we describe our visit to the establishment. But far from writing learnedly about the details of things seen, we have attempted to convey the atmosphere of such a visit by touching discursively upon this, that or the other item of equipment, process or experiment that attracted for a few minutes our attention. Three things particularly impressed us. The first was the costliness of much of the equipment needed for nuclear research, and for researches into the very varied facets of the application of nuclear energy, and the second was the width of the range of activities carried on. The third related to secrecy. It seemed to us to verge upon the absurd that secrecy should so long have surrounded much of the work of the establishment. What can be learned by a rapid visit to Harwell relates, of course, much less to the details of the discoveries being made and to the knowledge being gained than to the lines of advance being pursued and the kind of equipment available for pursuing it. But any physicist having some fundamental knowledge of the nucleus, any chemist with an understanding of chemical processing, any engineer with some appreciation of what goes on in a reactor, can set down without difficulty what lines of research are likely to be pursued at Harwell, and any actual worker in similar fields abroad could compile the list with considerable precision. One of the facts revealed by the Geneva conference was that much the same lines of research were being pursued by scientists and engineers in each participating country and another was that they were being pursued with much the same ability and insight. Rates of advance, it was revealed, had not, indeed, been quite the same. But that difference could be accounted for wholly by such extraneous factors as the amounts of money countries could afford to spend and quantities of fissile material available for research. Had there been less secrecy, the nations would not have needed, individually, to carry out, each under its own security veil, largely identical experiments; a vast duplication of effort would have been avoided. In short, in visiting Harwell and in whole-heartedly welcoming the new departure of "Open Days," we were driven to wonder why such "Open Days" had not been held long ago.

EUROPE'S ENERGY

It is very commonly assumed that the economic and other difficulties under which this country has laboured ever since the war are experienced by us alone. The assumption is insular. Many of the problems that beset us beset other nations of Western Europe, too. The rate of production of coal in Britain has been, ever since the war, disappointing. Our economic difficulties, it is suggested—though we, personally, doubt the truth of it—are exaggerated by the need to import fuel. Blame is cast on the miners for not working harder, and on the National Coal Board for its failure to sink new pits and to mechanise workings fast enough, and for its inability satisfactorily to manage its affairs or balance its accounts. Yet, in fact, these are not troubles we suffer in isolation. They are troubles shared in common by European nations. Nor are they particularly new. As is revealed by an O.E.E.C. report which lies before us as we write, entitled "Europe's Growing Needs of Energy—How Can They Be Met ? ", they stem from as far back as 1927. In that year for the first time, Western Europe which had formerly exported energy became a net importer. Ever since and to a growing extent, imports of energy have exceeded exports ; and since the war, in Europe as a whole, not in Britain alone, the failure of the coal mines to expand output at anything approaching the increase in the demand for energy has exaggerated the dependence upon imported supplies. By 1975, according to calculations that seem to us rather more likely to prove conservative than extravagant, the gap between primary energy consumption and indigenous production is estimated to reach 445 million tons of coal equivalent. Against that figure it is estimated that nuclear power stations are unlikely by that date to be generating more than 80,000,000 tons of coal equivalent ; and even if that estimate proves unduly pessimistic, there cannot be any hope that anything like five times as much energy can be so generated annually within twenty years. It is the purpose of the report to examine what are likely to be the consequences for the European economy and what actions are desirable. The report is well worth reading.

A Seven Day Journal

Rocket Propulsion

ON Tuesday last, at the Rocket Propulsion Department of R.A.E., Westcott, we were able to inspect one of the rockets built to carry instruments to altitudes of 100 miles during the coming International Geophysical Year (see THE ENGINEER, August 12, 1955). The "Raven," as it is called, is a large, simple solid-propellant motor giving 11,500 lb thrust for no less than thirty seconds. Initial ground firings will take place at Westcott and trial launches at Woomera. A demonstration was given of a small, solid boost rocket, a "Mayfly" with a 260 lb cordite charge, providing 18,000 lb thrust for 2·7 seconds. Among the liquid fuelled rockets displayed were the "Beta," with two combustion chambers swivelling about perpendicular transverse axes and intended to lift from the ground a Fairey vertical take-off project, and the "Gamma," a controllable two-chamber motor offering thrusts of 8000 lb for take-off, 2000 lb for combat and 800 lb for cruise, on high test peroxide and kerosene. Interesting engineering techniques associated with these rockets were the forming of bodies by deep drawing in the manner of a shell case, 0·19 per cent carbon steel being formed into a 9in diameter cylinder 53in long, and the continuous casting of cylindrical fuel tank billets in A.C.9 light alloy. The results of a great deal of investigation into combustion chamber materials suggested that ceramics such as silicon carbide would outlast resin bonded asbestos for the nozzle, while experiments had been performed on gas-cooled porous walls sintered from bronze or stainless steel. Research for guided weapons included examination of the transmission of radio waves through the ionised exhaust stream. Several small test beds for rockets and gas generator turbines were in use, while a stand to run a liquid fuel motor of 200,000 lb thrust was under construction.

European Energy Consumption

THE Organisation for European Economic Co-operation has published a report surveying present and future demands for all forms of energy in Europe, and entitled "Europe's Growing Energy Needs—How Can They Be Met?" European energy consumption in 1955 was equivalent to 730 million tons of coal, and in 1975 it is likely to reach a figure equivalent to 1200 million tons of coal, it is stated. The report was prepared by the O.E.E.C. Commission for Energy, under the chairmanship of Sir Harold Hartley, president of the World Power Conference. The Commission has made forecasts of Europe's energy requirements for 1960 and 1975; four different methods of forecasting were used. The Commission considered what part of total requirements could be covered in 1975 by the production of primary energy in Western Europe on the basis of present plans, and estimated about 750 million tons coal equivalent, excluding nuclear energy developments, as against about 580 million tons coal equivalent in 1955. The report emphasised that it would be quite erroneous to believe that nuclear energy would make large contributions to the supply of energy in Western Europe in the next twenty years (less than 8 per cent of total requirements by 1975). The remaining gap between energy requirements and indigenous supplies would therefore have to be bridged by imports of coal and oil, the cost of which would amount in 1975 to about 5000 million dollars at present prices. This might present a serious problem for some countries in its effect on the balance of payments. The Commission felt that member countries should make a determined effort to develop further their indigenous production of all forms of energy. All reserves of energy would be needed in the future, and coal would be the mainstay of the energy economy in Western Europe for many years to come. Coal must be given the outlook of a modernised and stable industry, it was asserted.

The Engineer
100 Years Ago
(JUNE 6, 1856)

"TRANSIT BETWEEN THE PACIFIC AND THE ATLANTIC OCEANS"

"The establishment of a free transit across the narrow isthmus which connects North and South America is a subject for the special consideration of all commercial nations. Its importance to us is little if anything less than the establishment of the route through the Isthmus of Suez, the perfecting of which, by a canal, appears now happily to be no longer a question involved in doubt. The former forms part of the great highway to our Australian Colonies, as the latter does to India, and the time has now arrived when an uninterrupted transit should be opened, free to all nations, well-guarded from any possible interruption on political grounds; and more than this, the governments of the respective countries through which they pass should be such as are favourable to the advance of commerce and solicitous for its growth. The American Government appears fully alive to the importance of this subject. . . .

"Indeed, the United States Government took steps at an early day to assure suitable means for commercial transit by canal or railway, and endeavoured, though unsuccessfully, to obtain from Mexico the right of way at the northern extremity of the isthmus, by way of Tehuantepec. . . . It appears but too clear that the unsettled condition of the Spanish-American Republics necessitates some interference from without, as a continuation of the revolutions and wars with which they have hitherto been agitated, must render them quite unable to protect foreign interests within their territory, and render any arrangements for a free passage through it, at least uncertain, if not impossible. We anxiously await the termination of the questions now pending, but so long as the main object is attained, we should be inclined to submit to conditions which, under other circumstances, would not be possible."

Pilot Plant for Underground Gasification

LAST Monday, the Minister of Fuel and Power, Mr. Aubrey Jones, said in Parliament that the technique of underground gasification had now reached the point at which the establishment of a pilot scale plant was desirable. The National Coal Board and the Central Electricity Authority, within their respective spheres, were accepting responsibility, as from July 1st, for the planning and construction of the pilot plant and had undertaken to explore the possibilities of exploitation on a commercial scale. Details of the transition to those new arrangements, Mr. Jones intimated, were now under discussion between his Ministry and the two authorities concerned. He went on to say that he had "indicated to both of them the importance of developing with the utmost expedition this important new technique." To this, the Minister added that he had expressed his wish that private enterprise should be associated with the work, particularly so that full advantage of it could be taken in overseas markets. The Minister was then asked "why he had not been able to entrust the whole of this work to private enterprise?" His answer was "for a statutory reason and a practical reason." As the statute now stood, he explained, the National Coal Board was the sole authority responsible for the exploitation of the country's coal resources. The practical reason was that it was desirable that one authority should determine which coal deposits should be exploited by underground gasification.

Unveiling of Mulberry Harbour Model

A SERIES of scale models of Mulberry Harbour were unveiled on Wednesday at the Arromanches memorial museum, situated on the seafront above the Normandy beaches where the British forces landed on their invasion of the Continent twelve years ago. The two prefabricated transportable harbours—each the size of Dover—are, of course, well-known as one of the primary wartime achievements of British civil engineering. They were towed under escort to the Normandy coast to provide a system of off-shore piers to land 10,000 tons of supplies a day on the shallow beaches, a feat matching the scale of the invasion itself. The display at the Arromanches Museum consists of five models demonstrating the principal units and the design of the Mulberry Harbour. It occupies an area of 76ft by 10ft. Funds for the museum were raised by subscriptions organised by the D-Day Commemoration Committee and a British contribution was sponsored by the British Constructional Steelwork Association and the Federation of Civil Engineering Contractors. The guest of honour at the unveiling was Mr. Duncan Sandys. The five models were built in Britain by Bassett-Lowke, Ltd.

Maudslay Society

THE annual luncheon of the Maudslay Society was held in London on Tuesday, May 29th. The visitors were welcomed in a toast given by Major J. E. Duckham and, in replying on their behalf, Mr. L. S. Atkinson spoke of the value of the Maudslay scholarships and the work involved in the selection of suitable candidates. The toast of the Society was then proposed by Lord Sempill, who dealt with the work of Henry Maudslay. Maudslay, he said, was a great engineering pioneer and one of the founders of mechanical engineering in the modern sense. It was on the work of such geniuses that mechanical progress was based, and in speaking of some of Maudslay's famous inventions, Lord Sempill pointed out that the early blacksmiths were the forerunners of the great industrial revolution. Maudslay, he said, was a "king amongst blacksmiths" and his constant endeavours to attain precision in manufacture had played an important part in the development of his own many outstanding pieces of equipment and those of some of his famous contemporaries. In responding to the toast, Mr. W. W. S. Robertson, the president of the Society, spoke of the satisfactory financial state of the Society and of the success it had had in establishing the Maudslay scholarships. He would like to have seen a larger number of applications for the scholarships from boys who were otherwise not at present eligible for university grants.

Concept of Irrigation Diversion Headworks

By S. LELIAVSKY Ph.D., M.I.C.E., M.Am.Soc.C.E.

Broadly speaking, the basic object of a diversion work is to raise the water surface in the river to the level required to command the main diversion canal. This object may be achieved either by pumps, or by building a barrage, or by a long approach canal, the slope in which is flatter than in the river. The technical and economical advantages of these three different schemes are examined and contrasted in the following article. Up to a point, they reflect on the proper choice of the main design parameter : the head. This aspect of the problem, and all its multiple implications, complete the discussion.

WHILE they belong to the same group, or family, of engineering works, regulators and other works, whether large or small, built on irrigation canals, on the one hand, and movable weirs, barrages and dams constructed on alluvial rivers, on the other, constitute two distinctly different design problems. This difference is the combined result of several causes. It will be observed, in the first instance, that structures such as regulators are a specifically irrigation class of work, which is not encountered in other branches of civil or hydraulic engineering. It is therefore only natural that its evolution has led to a standardisation of type, which has materialised into a code of empirical laws. In contradistinction to this stabilising tendency, a weir, or movable dam, built on a river of some size, apart from irrigation, may serve also a variety of other objects, such as improving navigation facilities, hydraulic power production, and so on. It affords, therefore, a much wider field of opportunity for the exercise of the creative engineering genius. This explains the diversity of design principles incorporated in modern dams, weirs and barrages.

It is therefore out of the question to attempt framing these designs by means of ready-made rigid rules, such as those capable of being formulated for minor works on distributary irrigation canals. Headwork design must therefore be dealt with on different lines, viz. a descriptive and analytical comparison of various types, leaving, nevertheless, a wide margin for the application of the personal ability of the designer. It is obvious, therefore, that, using in practice the material presented in the following columns, calls for greater maturity and deeper insight than is the case with the rules and methods applicable to the design of minor irrigation works, such as regulators.

Another characteristic point about the design and construction of headworks—as opposed to irrigation regulators and other canal works—is the importance of the methods employed in carrying out the work in the channel of a large alluvial river, particularly in connection with the construction of temporary sudds and the dewatering of the enclosure. This, indeed, may frequently constitute the most important problem of the whole project.

Barrage Versus Pumping Station

Still another peculiar aspect of headworks design is the variety of alternative methods that can be employed to achieve the same object, i.e. to control the water level in a river. When we deal with regulators or canal weir, there is usually no other substitute that can be used instead to attain the same purpose. But a weir or barrage over a river may frequently be replaced either by a pumping station or by a long canal running parallel to (and at a flatter slope than) the river, and taking off some distance upstream of the irrigated fields. Better to explain this last alternative, attention is called to Fig. 1, which represents graphically the main principle of this " third " solution.

It is therefore clear that the designer must be capable of realising the relative advantages of the three alternatives, and to choose among them the one which suits best the particular conditions of the case. A few

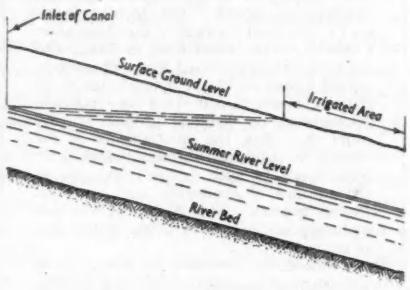


Fig. 1—Sketch illustrating third solution

words on the subject appear, therefore, to be called for at this point of the discussion.

In the first instance comes the question of the cost. In comparing the economic advantages of several schemes comprising both initial capital expenditure and yearly running expenses it is customary to convert both of them to one single basis. That is to say, we must either represent the economic analysis of the case in terms of a revenue account or reduce it to an assessment of capital values.

Elements of Economic Analysis

In discussing the mechanism of valuation it is most convenient to assume, for simplicity of exposition, that the capital to be invested in an engineering work is to be borrowed. It will then be clear that, in addition to paying the annual interest, we must also repay the capital itself at the expiration of a certain number of years. This period is determined by the estimated length of the practical life of the proposed work, at the end of which it will cease to be effective. Provision is made annually for the repayment of this capital. Each of these annual payments is supposed to be immediately invested at compound interest. Taken together for a certain period of years, they constitute the sinking fund, which, at the end of the period of effective life, must be equal to the capital invested. Depreciation of the value of an engineering work may either be due to wear and tear, gradual deterioration, depletion or obsolescence. By this last term we understand the premature end of the useful life of an engineering work or device, due to the development of new, improved means for the achievement of the same purpose.

Maintenance and running expenses are respectively the cost of keeping an engineering work in serviceable condition and the expenditure on labour, materials, consumable goods, &c., required for operating the scheme.

To save time in looking up textbooks on the subject* the main formulæ relating to these various concepts of engineering economics are given below :

(*a*) Sum to which £1 will amount with compound interest at r in n years,

$$S=(1+r)^n.$$

(*b*) Sum which at compound interest at r will amount to £1 in n years,

$$\frac{1}{(1+r)^n}$$

This is also the present value of £ in n years.

(*c*) Sum to which an annuity of £1 per year will amount at compound interest at r in n years (sinking fund),

$$\frac{(1+r)^n-1}{r}.$$

(*d*) Annuity which with compound interest at r will amount to £1 in n years,

$$\frac{r}{(1+r)^n-1}.$$

(*e*) Sum which will produce £1 per year, with interest at r, capital and interest being extinguished in n years (present value),

$$\frac{(1+r)^n-1}{r(1+r)^n}.$$

These formulæ are usually presented in tabulated form in textbooks, but as their use in engineering is much less frequent than in economics, and since the object of this discussion is to explain an engineering principle, rather than to give a lesson in bookkeeping, these tables are not reproduced here, and in the examples which follow the formulæ are applied directly.

Examples

In order not to encroach on the controversial aspects of the present Egyptian irrigation policy and thus to preserve the strictly academic spirit of the present exposition, the first example selected for quotation dates as far back as the time before the construction of the Makwar dam (1920), when adverse criticism attempted to prove that a pumping station, for the area to be reclaimed (which at that time was about 300,000 acres), represented the best policy. Calculations were then carried out by the offices concerned, in order to determine the economic minimum area that would justify the construction of a barrage. Characteristically, the variable factor was the area only, for the conditions at the headworks were assumed to be practically the same for all the irrigated area of Upper Egypt. Also, the length of the useful life of a barrage was taken to be infinite, which meant that no sinking fund was required to be introduced in the analysis of the barrage economics.

Unorthodox as they may appear from the accountants standpoint, these assumptions form a true statement of a perfectly clear engineering concept, and as such they yield a definite solution to a technical problem, under the conditions set out by the designer.†

To solve the problem under these particular

* *Cf.*—R. N. and W. G. Garter, *Advanced Accounts*. Also a pamphlet on "Engineering Economics," edited by the Institution of Civil Engineers, London, 1947.

† Quoting from *An Introduction to Engineering Economics*, published by the Institution of Civil Engineers, London, page 8: "The accountant or the actuary no doubt uses the mechanism (i.e. the fundamental mechanism of finance) more meticulously, but in engineering the technical components must be devised and put in their proper places by the engineer."

conditions, the following information was collected.

Two irrigation pumping stations, then at work in Egypt, namely the Korimat and the El-Lessi stations (head 8m) were taken as a basis for the estimate. They irrigated 22,981 and 20,413 feddans respectively (a feddan is the Egyptian unit of area, very nearly equal to 1 acre). The capital cost per feddan for these two stations was L.E.4·200 (an Egyptian pound, L.E., costs 2½ per cent more than a pound sterling, £), whereas the yearly expenses were on the average L.E.32 per annum.

From these figures the following table was computed :—

1	2	3	4	5	6
Area in feddans	Engaged capital at L.E.4·200 per feddan	Yearly working expenses at L.E.0·320 per feddan	Yearly expenses capitalised at 5 per cent	Original value of sinking fund at 6 per cent for twenty years	Total (2)+(4)+(5)
	L.E.	L.E.	L.E.	L.E.	L.E.
70,000	294,000	22,400	448,000	91,669	833,669
77,000	323,400	24,640	492,800	100,836	917,036
80,000	336,000	25,600	512,000	104,765	952,765
90,000	378,000	28,800	576,000	117,860	1,071,860

In this table the entries of column 4 are obtained from those of 3 multiplying them by 100/5=20, whilst the figures in 5 are calculated from those of 2, using the factor given earlier under heading (*b*), namely,

$$\frac{1}{(1+r)^n}=\frac{1}{(1+0{\cdot}06)^{20}}=0{\cdot}3118.$$

The totals obtained in that manner were then compared with the figures referring to the cost and maintenance of two Upper Egyptian barrages—those of Assiut and Esna—as shown below :

Barrage	Cost	Yearly expenses	Capitalised yearly expenses	Total	Corresponding area if served by pumps
	L.E.	L.E.	L.E.	L.E.	
Assiut	870,000	2,255	45,100	915,100	77,000
Esna	860,000	10,543	210,860	1,070,860	90,000

The difference between the yearly expenses for the two barrages seems to have been due to the rubble dumped downstream of the Esna barrage during flood.

Should the figures of the tables be taken at their face value, a barrage would be the more economical proposition for any area greater than about 100,000 feddans.

The problem, however, is not as simple as it appears from this estimate, which is introduced here as an example intended to explain the economic approach to irrigation problems in general, but by no means as a firmly established numerical criterion.

It may nevertheless be of interest to explore the case somewhat further ; for instance, let us consider the conditions as they existed some fifteen years later. We will take two contemporary works (1930–35), i.e. the Nag-Hammadi barrage, on the one hand, and the isolated basins pumping scheme, in Upper Egypt, on the other. The cost of this barrage, inclusive of the Fouadia and Faroukia head regulators depending on it, was about L.E.2,270,000, which, together with the capitalised yearly expenditure and other expenses, amounts in round figures to a total of about L.E.2,500,000.

On the other hand, for the isolated basins scheme‡ we have :

Cost of power station	L.E.256,892
Cost of transmission line, including transformer station	L.E.107,773
Cost of electrically driven irrigation pumping stations	L.E.423,323
Total	L.E.787,988

‡ Courtesy of Kosheiri Bey, Director of the Pumping Stations, M.P.W.

The corresponding yearly expenditure for 1935–36 was as follows :—

	Running cost	Departmental and interest on capital
	L.E.	L.E.
Power station	18,895	23,171
Pumping station	9,363	32,221
Transmission lines	512	7,588

The head is about 8·5m.

Attention is called to the fact that the area served by this scheme, i.e. about 50,000 feddans, is composed of a number of isolated plots, at considerable distances from one another, which could not have been served by a barrage without building a network of abnormally long, and therefore rather expensive canals. For a fair comparison between pumps and barrage, all expenses on electrical transmission lines must therefore be excluded ; but even then the extra cost for housing the power and pumping machinery in two separate stations must still create a bias in favour of the barrage—a consideration to be borne in mind in assessing the true value of the results of the economical analysis of the alternative schemes.

Instead of a table, as in the first example, the required solution will now be obtained in the form of an equation. In fact, let the critical area be x feddans, and let P and Q be the initial cost of the pumping scheme per feddan and the corresponding yearly expenditure per feddan per day. The critical area can then be found from

$$x\left\{P\left[1+\frac{1}{(1+r)^n}\right]+\frac{Q}{r_1}\right\}=A,$$

in which A is the cost of the barrage plus the capitalised expenditure thereon.

Substituting in this equation,

P=L.E.13·604 per feddan.
Q=L.E.0·565 per feddan per day.
r=0·06.
n=20 years.
r_1=0·05.
A=L.E.2,500,000.

we find

$$x=\frac{2{,}500{,}000}{13{\cdot}6\left(1+\frac{1}{(1+0{\cdot}06)^{20}}\right)+\frac{0{\cdot}565}{0{\cdot}05}}=71{,}164 \text{ feddans.}$$

This area is slightly less than the average critical area obtained from the first estimate, but this difference was only to be expected, because of independent stations for pumps and motors. It follows that in principle both estimates are in close agreement.

Effect of the Water Table

There is, however, another side to the problem which so far has not been considered, namely, that of the water table. Much attention has in fact been recently devoted in Egypt to the undesirable effects on agriculture, as well as on the general standard of health of the population, consequent on the rise of the ground water level, due to over-intensive perennial irrigation ; particularly in the districts, such as the Galioubieh, which are still under indifferent drainage conditions. In this connection it must be realised that under its normal regimen of water levels a large river, such as the Nile, acts as a powerful drain during the low-level period. Regulation on a barrage causes, therefore, a material alteration in the yearly pattern of subsoil water levels in its area of influence. As an example we can cite the case of the Nag-Hammadi barrage, for which a set of observations of the water table in the adjoining area were published§ by H. E. Mohamed Chafik Pasha, the late Minister of Public Works, Egypt.

To derive a general conclusion from these observations, they were contrasted with the ground water levels observed by Ferrar‖ in 1908, in the same wells. The table at the foot of the page was thus obtained.

In inspecting this table it will be observed that during the low stage of the river, i.e. in the critical months of June and July, the head maintained on the barrage in 1935 caused the water table in the cultivated area to rise, depending on the distance from the river, as shown in the following table :—

Month	Rise of level in river	Rise of water table, at distances from river		
		½ kilo	2 kilos	3 kilos
June...	5·08	3·55	2·90	1·30
July...	5·16	3·70	2·95	1·20

The quoted paper concluded that the depth of the water table below surface level had been reduced from 5·70m to 2·30m near the river, and from 2·95m to 1·65m in the area bordering the desert.

Another approach to the same problem is to compare the number of days per year during which the depth of the "dry" soil below surface level is less than 1·50m, which is considered in Egypt a minimum. The

§ Mohamed Chafik Pasha, "Les Eaux Souterraines de la Région de Nag-Hamadi," *Le Caire*, 1936.

‖ H. T. Ferrar, M.A., F.G.S., "The Movements of Subsoil Water in Upper Egypt," Cairo, 1911.

Ground, Water Levels in Metres Above a Conventional Mean Sea Level.

	River		½ kilo from river		2 kilos from river		3 kilos from river	
	1908	1935	1908	1935	1908	1935	1908	1935
January	62·85	65·50	63·40	66·12	64·00	66·00	64·30	64·50
February...	62·40	65·62	62·75	65·50	63·35	65·60	63·80	64·50
March	61·90	65·34	62·15	65·36	62·90	65·48	63·40	64·50
April	61·25	65·15	62·05	65·55	62·80	65·50	63·35	64·60
May...	60·80	65·12	62·00	65·45	62·75	65·50	63·35	64·60
June...	60·45	65·53	61·90	65·45	62·70	65·60	63·30	64·60
July...	60·60	65·76	61·85	65·55	62·65	66·60	63·40	64·60
August	63·75	66·34	62·70	66·50	63·10	66·30	63·30	64·65
September	68·10	68·18	67·30	67·95	65·55	66·90	64·55	65·00
October	68·40	68·33	67·90	67·60	67·40	66·90	65·80	65·30
November	66·60	66·15	66·90	67·20	66·50	66·80	65·40	65·30
December	64·65	65·57	65·15	66·65	65·35	66·25	65·10	65·05

same paper contains the following figures :—

Year	Number of days when the depth of the water table is less than 1·50m below ground level			
	½ kilo from river	1 kilo from river	2 kilos from river	4 kilos from river
	Days	Days	Days	Days
1908...	80	80	80	120
1935...	150	120	160	160
Difference ...	70	40	80	40

Certain points about these figures might possibly be subject to discussion, but they are reproduced here, not as supporting any specific conclusion, but merely as an illustration of a principle, viz. to show that regulation on a barrage affects to a certain degree the water table over a rather wide area, which means that in fixing the water level to be maintained behind a barrage, apart from the fact that it must command the area to be irrigated, one must also take into account that it should not cause the water table to rise to a harmful level.

Since these two conditions are frequently mutually contradictory, or even exclusive, it is now believed that an irrigation barrage must not be left to work alone, but must perform its duty in conjunction with a main carrier canal, designed on the principle of the " third " alternative shown in Fig. 1 ; i.e. the barrage must be located at a certain distance L upstream of the area depending upon it, and this area must be served through a canal with a slope s_1, less than the slope s in the river. If H_0 represents the difference of level between the irrigated fields and the river, that is to say the total " lift," the head H on the barrage will be

$$H = H_0 - L(s - s_1).$$

Should the sloping level of the irrigated fields be taken as datum, it will then follow that by means of the carrier canal the designed barrage level has been reduced by $L\ (s - s_1)$, which solves the water table problem. At the same time, the head on the barrage is also reduced.

Though the fact may not be obvious to the layman, this is indeed the main principle incorporated in all the Upper Egyptian barrages ; for instance, the irrigated area depending on the Assiut Barrage only begins at Deirout, and is supplied through the Ibrahimia Canal.

From lengthy experience under conditions prevailing in Upper Egypt, it is found that L is about 60km to 70km, s about 7cm to 8cm per kilometre, while s_1 is 4cm to 5cm per kilometre. Substituting these figures in the formula, the difference $H_0 - H$ is about 2·0m to 2·5m.

The Esna barrage remodelling furnishes a further illustration of the point. This barrage was originally built for basin irrigation only and was therefore designed to be regulated upon in flood, but the remodelling project prepared in 1938 provided (in the more or less distant future) for the conversion of all the served area to perennial irrigation and was therefore designed for more than 7m head in summer. Since it was believed that the barrage could not be strengthened to withstand more than 5m head, a subsidiary weir, with a lock, was proposed to be built behind it. For various reasons the project was then postponed and on resuming it in 1943 the question of levels was again gone into. It was then discovered that raising the water surface in the Nile to the proposed level might adversely affect the drainage conditions in the adjoining area. The new project was therefore designed on the assumption that the converted area depending on this barrage would start about 60km downstream, and that therefore a head of about 4·5m to 5·0m would suffice for free flow irrigation taking advantage of the Killabia Canal on the east, and the Asfun Canal on the west. These heads, it was found, would cause no harm to the cultivated area in the immediate neighbourhood of the barrage. The weir downstream of the barrage was therefore deleted altogether from the second project.

It will be clear from the foregoing discussion that in comparing the economical advantages of a pumping station with a barrage, the cost of the main canal must also be included in the estimate of the latter. This may possibly be explained in another manner also. The three pumping schemes referred to earlier (Korimat, El Lessi and the Isolated Basins) all work against a head of about 8·0m to 8·5m, whereas the head in the Upper Egyptian barrages does not exceed 5m, the difference being made up by the canal. This shows that the canal is an inherent part of the barrage scheme for raising the water level and that it must therefore be included in the comparison of costs, which will cause the critical area to be materially greater than in the first estimate.

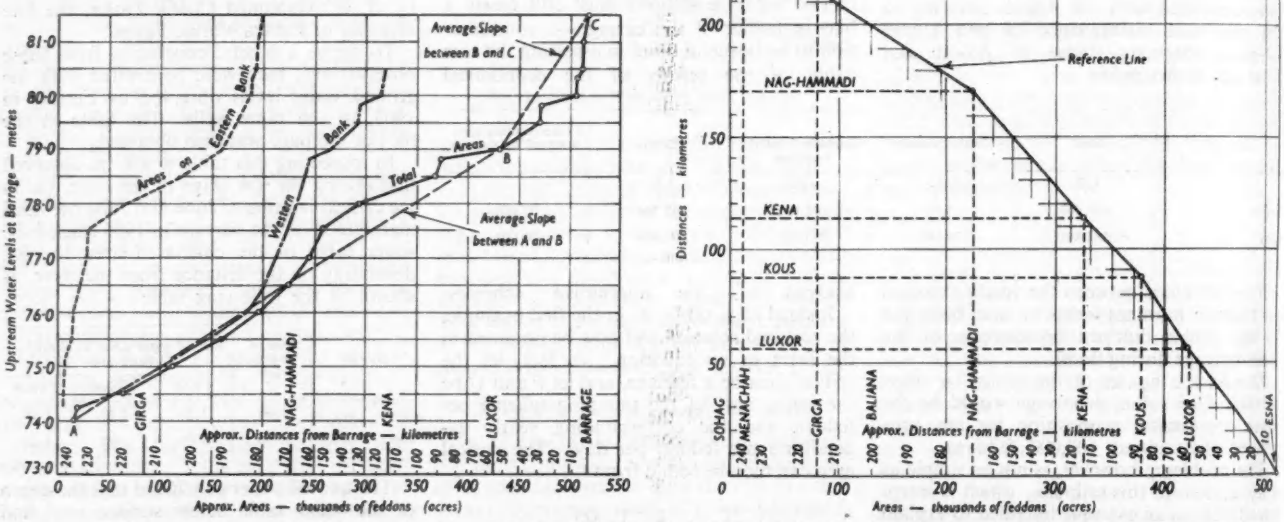
The study of the problems considered in the foregoing columns may frequently be simplified and facilitated by the use of various diagrams and charts, such, for instance, as that shown in Fig. 2, which was employed by the author in the early period of the discussions concerning the head for which the Esna barrage should be remodelled.

The object of this chart is to systematise the study of the interdependence between the head on the barrage, on the one hand, and the perennial area it commands, on the other. The computation is carried out assuming a 5cm per kilometre slope in the two main canals (Killabia and Asfun, on the eastern and western banks of the river, respectively) when their remodelling for perennial irrigation is completed.

In order to make the investigation more comprehensive a third scale is added at the bottom of the chart, namely, that of the distances from the barrage ; since, however, the areas are not necessarily proportional to the distances, an auxiliary chart (see Fig. 3) was used to solve graphically the scale problem.

In this diagram the distances to, and the corresponding accumulated areas of, the chief localities between Esna and Sohag are used as cartesian co-ordinates for drawing the basic reference line, and the intermediate divisions of the scale are then obtained by interpolation.

Reverting now to the main diagram, Fig. 2, it will easily be seen that, though admittedly approximate, it yields, nevertheless, a very definite result, in so far at least as the factors appearing in it are concerned. It will, in fact, be observed that up to a certain level (viz. 79·00) the average slope of the total area curve is nearly constant, corresponding to a steady increment of about 85,000 feddans per metre increase of head. Whereas above point B (see figure), the curve turns sharply upwards. This point yields therefore the obvious, so to speak, " natural " limit, beyond which a further increase of head ceases to be either economical or generally advisable. It is true that graphical computations do not always yield significant



Figs. 2 and 3—(Left) Diagram showing approximate areas capable of being irrigated by free-flow from Esna barrage, depending on the summer supply level, assuming a slope of 5cm per kilometre in main canals. (Right) Auxiliary diagram for the computation of the distance scale

results in so concise a form, which, of course, cannot be predicted beforehand ; still, practical experience with such computations develops what the French call " flair," i.e. a subconscious feeling which helps in selecting *a priori* the particular type of diagram that will later be found to furnish a satisfactory, significant result.

On the other hand, it should be realised that diagram, Fig. 2, was only one of the numerous stages in the rather lengthy history of the remodelling project in question, which took no less than ten years to complete (seven among which were spent on investigations). This is frequently the case with the remodelling projects for important existing structures, for any work done on them clashes with established routine and interferes, therefore, with a multitude of public, communal and individual interests, which must all be taken into consideration before a final decision is taken.

The diagram in question is nevertheless believed to be of interest as an illustration of the variety of the computation methods which a designer may be called upon to employ, in the general analysis of the structural problems he is entrusted to solve.

Buckling under Complex Loading

By A. N. PROCTER, M.Sc.(Eng.), A.M.I.C.E., M.I.Struct.E.

No. I

The purpose of this article is to show how strain energy methods of calculation may be used to investigate the elastic stability of structural members under the action of complex systems of loading, and to estimate the secondary bending produced by a combination of working forces and moments. Some experimental data are given to show the accuracy to be expected and to show the limits of slenderness within which the results would apply.

IN a previous article[1] the writer showed how a number of fundamental buckling problems may be solved with reasonable accuracy by the use of simple energy equations. The following calculations refer primarily to members of simple cross-section and of metallic materials, although brief reference is made to timber, since reliable published test data on the buckling of structural members of other materials under complex loading do not appear at present to be available. The results are intended to apply to what are here described as " flexible " or " Euler " members, but they may be adapted to apply also to " semi-flexible " members in those

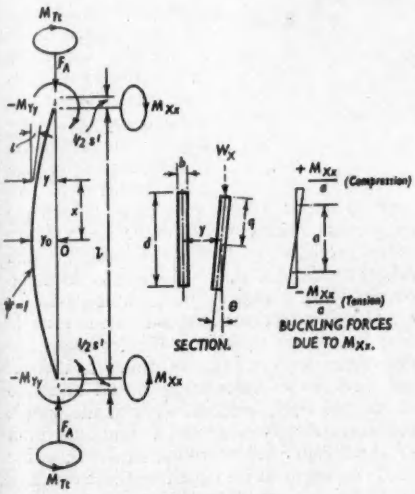


Fig. 1

cases where the properties of the materials remain approximately constant beyond the Euler limit. It is assumed that the cross-section of the member is such that it will not fail by local buckling.

Considering the elastic stability of a flat straight member of length l with round or freely hinged ends as represented in Fig. 1, and assuming that the lateral deflection normal to the depth may be expressed in a form, $y = y_0 \cdot \cos \pi x/l$, where y_0 is the deflection at 0; the work done by the axial force F_A in causing a small deflection y_0 would be[1, 2]

$$\tfrac{1}{2}\int_{-l/2}^{+l/2} F_A\left(\frac{dy}{dx}\right)^2 dx \,.\, = \frac{\pi^2 \,.\, F_A \,.\, y_0^2}{4l},$$

and assuming the lateral slope at a distance x from the origin is ι, the work done by the uniform lateral bending couples $-M_{Yy}$ would be[2]

$$-\tfrac{1}{2}\int_{-l/2}^{+l/2} M_{Yy}\frac{d\iota}{dx}\,.\,dx = -\tfrac{1}{2}\int_{-l/2}^{+l/2} M_{Yy}\cdot\frac{d^2y}{dx^2}\,.\,dx$$
$$= \pi \,.\, M_{Yy} \,.\, \frac{y_0}{l}.$$

The couples M_{Yy} are here considered negative relative to the direction of buckling. The work done by a uniform transverse bending moment M_{Xx} which causes the beam to buckle laterally also to twist (Fig. 3[3]) is

$$\tfrac{1}{2}\int_{-l/2}^{+l/2} \frac{M_{Xx}}{a}\left(\frac{d(y+\frac{1}{2}a\,.\,\theta)}{dx}\right)^2 dx$$
$$-\tfrac{1}{2}\int_{-l/2}^{+l/2} \frac{M_{Xx}}{a}\left(\frac{d(y-\frac{1}{2}a\,.\,\theta)}{dx}\right)^2 dx = \frac{\pi^2 M_{Xx}\,\theta_0\,.\,y_0}{2l},$$

θ being the angle of twist at a point x from 0 and is equal to $\theta_0 \cos . \pi x/l$ and a is the moment arm of the tensile and compressive forces in the member due to M_{Xx}. Also the work done by a uniform torque would be $\frac{1}{2}M_{Tt} \,.\, \theta_0$. The strain energy of flexure in terms of the flexural rigidity $E \,.\, I_Y$ would be[1]

$$\tfrac{1}{2}\int_{-l/2}^{+l/2} E \,.\, I_Y\left(\frac{d^2y}{dx^2}\right)^2 dx = \frac{\pi^4 E \,.\, I_Y \,.\, y_0^2}{4l^3},$$

and the strain energy of torsion in terms of the torsional rigidity $G \,.\, I_T$ would be[1]

$$\tfrac{1}{2}\int_{-l/2}^{+l/2} G \,.\, I_T\left(\frac{d\theta}{dx}\right)^2 dx, \text{ which is } \frac{\pi^2 \,.\, G \,.\, I_T\theta_0^2}{4l}.$$

Equating now the strain energy to the work done, when the deflection y_0 in the

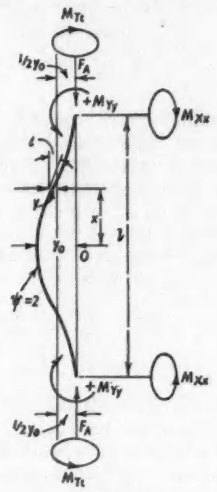


Fig. 2

direction of buckling is small, the energy equation for a flexible (Euler) member would be

$$\frac{\pi^2 \,.\, F_A \,.\, y_0^2}{4l} + \frac{\pi \,.\, M_{Yy} \,.\, y_0}{l} + \frac{\pi^2 \,.\, M_{Xx} \,.\, \theta_0 \,.\, y_0}{2l}$$
$$+\tfrac{1}{2}M_{Tt} \,.\, \theta_0 = \frac{\pi^4 \,.\, E \,.\, I_Y \,.\, y_0^2}{4l^3} + \frac{\pi^2 \,.\, G \,.\, I_T \,.\, \theta_0^2}{4l},$$

so that

$$F_A = \frac{\pi^2 \,.\, E \,.\, I_Y}{l^2} + \frac{G \,.\, I_T \,.\, \theta_0^2}{y_0^2} - \frac{4M_{Yy}}{\pi \,.\, y_0}$$
$$- \frac{2M_{Xx} \,.\, \theta_0}{y_0} - \frac{2M_{Tt} \,.\, l \,.\, \theta_0}{\pi^2 \,.\, y_0^2},$$

differentiating with respect to θ_0 and equating to zero :

$$\frac{dF_A}{d\theta_0} = \frac{2G \,.\, I_T \,.\, \theta_0}{y_0^2} - \frac{2M_{Xx}}{y_0} - \frac{2M_{Tt} \,.\, l}{\pi^2 \,.\, y_0^2} = 0.$$

Thus

$$\theta_0 = y_0 \frac{(M_{Xx} + M_{Tt} \,.\, l/\pi^2 \,.\, y_0)}{G \,.\, I_T} \quad . \quad . \quad . \quad (1)$$

Putting $P_Y = \pi^2 \,.\, E \,.\, I_Y/l^2$ the critical axial load (F_A'') is found to be

$$F_A'' = P_Y - \frac{4M_{Yy}}{\pi \,.\, y_0} - \frac{(M_{Xx} + M_{Tt} \,.\, l/\pi^2 \,.\, y_0)^2}{G \,.\, I_T}$$
$$. \quad . \quad . \quad . \quad . \quad . \quad (2)$$

TABLE I—*Coefficients in Formulæ 3 and 4 of Maximum Values of Free Bending Moments, Axial Forces and Torques Applied to Single Spans with Two Supports*

Kind of free bending moment	λ—Transverse B.M.			β—Lateral B.M.		
	$\psi=1$	$\psi=1{\cdot}5$	$\psi=2$	$\psi=1$	$\psi=1{\cdot}5$	$\psi=2$
Uniform bending moment	1·0	1·0	1·0	1·27	0·85	0·64
Central point loading	0·74	0·83	0·87	0·82	0·42	0·2
Loading at one-third points	0·89	0·96	0·97	1·06	0·5	0·22
Uniformly distributed loading	0·885	0·95	0·97	1·02	0·48	0·2
B.M. increasing from zero at mid-span	0·5	—	0·5	1·68	—	0·64

Kind of axial force or torque	α—Axial force			τ Torque
	$\psi=1$	$\psi=1{\cdot}5$	$\psi=2$	
Uniform	1·0	1·0	1·0	0·1
Increasing uniformly from zero at one end	0·55	0·5	0·5	0·07

ψ refers to axis of buckling.

TABLE II—*Buckling Tests on a Light Alloy 3in by 1½in "I" Beam Loaded at the Centroid, the Upper Flange and Lower Flange, by Dr. A. R. Flint.*[4]

Central Loads (W_X) in pounds, Critical Bending Moments ($\lambda M_{Xz}''$) in pounds inches.

E assumed $10{\cdot}7\times10^6$ lb per square inch, G assumed 4×10^6 lb per square inch, $I_Y=0{\cdot}147\text{in}^4$ and $I_T=0{\cdot}0263\text{in}^4$.

Span of beam (l) inches	Euler load (P_Y) pounds	Load at centroid			Load at top flange			Load at lower flange			
		W_X pounds	$\lambda M_{Xz}''$ lb-in		W_X pounds	$\lambda M_{Xz}''$ lb-in		W_X pounds	$\lambda M_{Xz}''$ lb-in		
			Test	Calc.		Test	Calc.		Test	Calc.	
168	550	240	7,450	7,580	228	7,100	7,130	260	8,080	8,030	Beam simply supported and freely hinged laterally. $P_Y=\frac{\pi^2E\,.\,I_Y}{l^2}$
156	638	280	8,100	8,180	260	7,500	7,650	300	8,670	8,710	
144	750	340	9,050	8,850	312	8,300	8,230	364	9,700	9,470	
132	890	392	9,580	9,650	364	8,900	8,910	448	10,970	10,380	
120	1,075	500	11,100	10,630	452	10,000	9,750	532	11,700	11,520	
108	1,330	600	12,000	11,800	540	10,800	10,700	668	13,350	12,900	
97	1,650	760	13,650	13,200	676	12,150	11,970	852	15,300	14,660	
84	2,200	996	15,500	15,200	876	13,600	13,490	1,112	17,300	17,120	

Critical bending moment calculated from $\lambda M_{Xz}''=\sqrt{G\,.\,I_T\,.\,P_Y}\mp\frac{4P_Y\,.\,q}{\pi^2\lambda}$

$\lambda=0{\cdot}74$ and $q=1\frac{1}{2}$in above or below the centroid.

Fig. 2 represents a member carrying similar loading and buckling in double curvature ($\psi=2$), taking the co-ordinate axis through the points of contraflexure, so that the co-ordinate y at a point x from the origin, 0, is then assumed to be $\frac{1}{2}y_0\,.\cos\,.\,2\pi x/l$, y_0 being the lateral deflection at 0. The critical value of F_A now is

$$F_A''=4P_Y-\frac{2M_{Yy}}{\pi\,.\,y_0}-\frac{(M_{Xx}+M_{Tt}\,.\,l/\pi^2\,.\,y_0)^2}{G\,.\,I_T} \quad . \quad . \quad . \quad . \quad . \quad (2a)$$

θ_0 being again as formula (1). The couples $+M_{Yy}$ are required to restrain the ends.

When the applied forces, bending moments or torque vary along the length of the member the general form of formula (1) is

$$\theta_0=\frac{y_0(\lambda M_{Xx}+\tau M_{Tt}\,.\,l/y_0)}{G\,.\,I_T} \quad . \quad . \quad (3)$$

and formula (2) becomes

$$\alpha F_A''=\psi^2\,P_Y-\frac{\beta M_{Yy}}{y_0}-\frac{(\lambda M_{Xx}+\tau M_{Tt}\,.\,l/y_0)^2}{G\,.\,I_T} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

α, β, λ and τ are coefficients of the max. values of F_A, M_{Yy}, M_{Xx} and M_{Tt} and ψ is the curve factor to represent the type of curvature of the buckling. Values of coefficients for simple variations of the applied forces, &c., including the effect of shearing forces, are given in Table I for three values of ψ.

When the bending moment M_{Xx} is caused by a transverse force or system of forces applied a distance q above or below the neutral axis (Fig. 1) an additional torque is produced which modifies the buckling effect of M_{Xx} accordingly. When the loading is applied to or above the compression side of the member the critical loading is decreased and when it is applied to or below the tension side it is increased. Solving for λM_{Xx} in formula (4) the critical bending moment, $\lambda M_{Xx}''$, applied at the neutral axis would be

$$\lambda M_{Xx}''=\sqrt{G\,.\,I_T\left(\psi^2P_Y-\alpha F_A-\frac{\beta M_{Yy}}{y_0}\right)}\mp\frac{\tau M_{Tt}}{y_0}\,.\,l \quad . \quad . \quad . \quad . \quad . \quad (4a)$$

When q is small compared with l the effect of the torque, $\mp W_X\,.\,q\,.\,\theta$, due to loading W_X, carried at or symmetrical about midspan is found to be $4\psi^2P_Y\,.\,q/\pi^2\lambda$ and in the absence of M_{Tt}, M_{Yy} and F_A the critical bending moment

$$\lambda M_{Yy}''=\sqrt{G\,.\,I_T\psi^2P_Y}\mp\frac{4\psi^2\,.\,P_Y\,.\,q}{\pi^2\,.\,\lambda} \quad . \quad . \quad (4b)$$

The negative sign applies when the loading is carried above the neutral axis (ref. Table II). For alternative derivations of this type of formula the reader is referred to reference.[5]

For any given combination of loading the deflection y_0 may be found by solving for y_0 in formula (4) and then the angle of twist may be found from formula (3), so that the lateral deflection of the extreme edges will be $y_0\pm\frac{1}{2}d\,.\,\theta_0$. When M_{Xx} and M_{Tt} are zero, $y_0=\beta M_{Yy}/(\psi^2P_Y-F_A)$ and if $-M_{Yy}$ is caused by an eccentricity (e) of the application of F_A, the central deflection when the ends are freely hinged is given by

$$y_0=\frac{4}{\pi}\frac{e\,.\,F_A}{(P_Y-F_A)} \quad . \quad . \quad . \quad (5)$$

the Perry formula for the deflection of an eccentrically loaded strut.[2, 6] Table III shows a comparison of Perry's formula and the well-known secant formula with deflection tests of eccentrically loaded solid round mild steel struts,[7, 8] and it will be seen that Perry's formula gives results which are slightly more accurate than the secant formula in this particular example. For an eccentrically loaded tie bar the sign of F_A is reversed, so that the central deflection $y_0=-4e\,.\,F_A/\pi(P_Y+F_A)$, giving results of equal accuracy.

When F_A, M_{Yy} and M_{Tt} are zero, formula (4*a*) reduces to the simple form of Mitchell's formula for the buckling of a flat plate and is here $\lambda M_{Xx}=\sqrt{G\,.\,I_T\psi^2P_Y}$. Mitchell[9] verified his formula by experiments on a 1·72in by 0·102in cross-section steel strip tested as a cantilever and also as a simply supported beam loaded at mid-span, and it was also verified by H. Carrington[10] on cantilevers of various cross-section and length with an average error of 4 per cent in ten experiments. Tests which have been made more recently by Dr. A. R. Flint[11] and others indicate that Mitchell's formula, possibly in a modified form, may be used for I and other sections, but published tests to date have been mostly on slender beams, so that there is no definite information how far the methods of calculation would apply to stiffer members, because, as with the simple column, there is evidently a minimum limit of slenderness below which buckling either does not occur at all or where these formulæ do not give reasonably accurate results, even when the material of the member is still in an elastic state.

It is found by experiment that Euler struts within certain limits of slenderness begin to deflect at loads which are considerably less than the buckling loads (P_Y). Table IV is taken from J. Christie's tests on tee section struts[12] as a typical illustration. All such deflections have been attributed to the effect of assumed imperfections in the struts or in the methods of loading, e.g. ref. [13], but Dr. E. H. Salmon[14] observes that assuming these deflections are caused entirely by eccentric loading or initial curvature of the test pieces, it is found from one of Tetmajer's

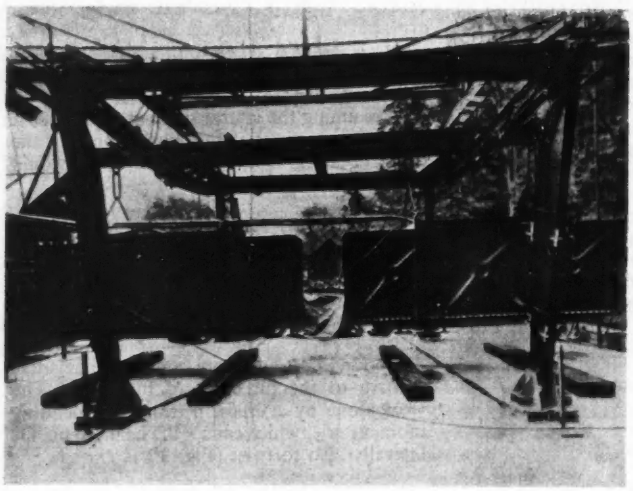


Fig. 3

TABLE III—*The Deflection of Eccentrically Loaded Solid Round Mild Steel Struts. Test Data Taken From "The Strength of Struts," by Professor A. Robertson*[7]

Diameter of bar	0·999in
Length (ends free)	22·25in
Slenderness ratio (l/k)	89·1
Eccentricity of loading	0·005in

(Load F_A) tons	Central deflection (y_0) 0·001in		
	Test	Secant	Perry
1·62	1·0	0·88	0·91
1·79	1·2	1·0	1·02
2·14	1·7	1·25	1·26
2·48	2·2	1·5	1·5
3·34	3·0	2·2	2·2
3·86	4·0	2·7	2·7
4·90	5·07	3·85	3·9
5·99	6·97	5·5	5·6
6·42	7·8	6·25	6·3
6·84	9·84	7·18	7·18
8·12	12·75	10·7	10·6
8·98	15·88	14·65	14·55
9·82	21·91	19·8	20·2
10·25	26·27	24·6	24·6
10·68	32·47	30·2	30·5
11·11	41·17	40·7	39·5
11·54	61·0†	(58)	(53·8)
(12·9)	P_Y	—	—

Diameter of bar	1·001in
Length (ends free)	22·5in
Slenderness ratio (l/k)	89·9
Eccentricity of loading	0·495in

Load (F_A) tons	Central deflection (y_0) 0·001in		
	Test	Secant	Perry
0·32	18	16	16
0·86	50	43	45
1·57	88	86	88
2·15	125	124	127
2·8	175	173	176
3·1	200	198	201
3·3	260†	(213)	(219)
3·35	305†	(218)	(223)
(12·8)	P_Y	—	—

$E=13{,}300$ tons per square inch.

Yield stress of material 20·3 tons per square inch.

† (Yield stress of material exceeded)

Secant formula $y_0=e\left(\sec.\frac{\pi}{2}\sqrt{\frac{F_A}{P_Y}}-1\right)$

Perry formula $y_0=1{\cdot}27\,e\,.\,\frac{F_A}{(P_Y-F_A)}$.

TABLE IV—*Buckling Tests on Axially Loaded 1½in by 1½in Tee Section Wrought Iron Struts, by J. Christie*[12]

E (average) assumed 29×10^6 lb per square inch. Yield point about 40,000 lb per square inch.

Mark No.	*l*/*k*	Section area square inches	Axial loads—1000 lb Central Deflection—inches (in brackets)									Final loads 1000 lb	$\pi^2 E.A.k^2/l^2$ 1000 lb	Permanent deflection, inches
Ends round (1in ball and plate)														
203	309	0·53	0·2 (0·06)	0·5 (0·08)	1·0 (0·24)							1·3	1·57	0
208	254	0·53	0·2 (0·02)	0·6 (0·05)	0·8 (0·06)	1·0 (0·07)	1·2 (0·09)	1·4 (0·12)	1·6 (0·15)	1·8 (0·2)	2·0 (0·3)	2·2	2·35	0·18
212	198	0·57	0·5 (0)	2 (0·03)	3 (0·09)	4·5 (0·6)						4·51	4·2	0·29
216	141	0·57	0·5 (0)	2 (0)	4 (0·03)	6 (0·09)						7·5	8·2	0·42
*219	84	0·54	0·5 (0·01)	3 (0·01)	6 (0·02)	9 (0·03)	12 (0·05)					13·73	21·9	0·45
220	66	0·57	0·5 (0·02)	6 (0·02)	12 (0·03)	15 (0·03)	18 (0·05)					18·82	(38)	0·38
221	47	0·53	0·5 (0)								18 (0·01)	19·5	—	0·37
222	47	0·53	0·5 (0)							12 (0·01)	15 (0·01)	16·82	—	0·21
223	28	0·56	0·5 (0)								crushed	23·2	—	—
Ends flat														
													$3\pi^2 E.A.k^2/l^2$	
43	301	0·54	0·3 (0·02)	1 (0·07)	2 (0·08)	3 (0·09)	4 (0·1)	5 (0·4)				5·02	5·1	0·1
†70	300	0·55	0·3 (0·12)	1 (0·17)	2 (0·22)	3 (0·4)						3·5	5·2	0·47
48	245	0·53	0·1 (0·03)	0·5 (0·02)	1 (0·03)	1·5 (0·05)	2 (0·06)	3 (0·09)	4 (0·12)	5 (0·17)	6 (0·31)	6·5	7·55	0·34
†72	244	0·54	0·3 (0·13)	0·5 (0·13)	1 (0·17)	1·5 (0·19)	2 (0·22)	2·5 (0·24)	3 (0·27)	4 (0·35)	5 (0·54)	5·0	7·8	0·62
56	132	0·56	0·5 (0·02)	2 (0·02)	4 (0·02)	6 (0·03)	8 (0·03)	12 (0·03)	14 (0·04)	16 (0·05)	18 (0·06)	19·5	(27·3)	0·95
59	75	0·56	0·5 (0)	2 (0·01)	6 (0·01)	10 (0·01)	12 (0·01)	14 (0·01)	17 (0·02)	20 (0·02)		21·4	—	0·4
63	37	0·52	0·5 (0·03)	3 (0·03)	6 (0·03)	9 (0·03)	12 (0·03)	15 (0·03)	18 (0·03)			20·9	—	0·14
65	19	0·52									25 (0·02)	28·1	—	0·06
66	19	0·52									20 (0·01)	23·8	—	0·06
67	19	0·52									crushed	28·6	—	—

* This strut buckled when well below the Euler load although the deflections were small.
† The original curvature or eccentricity in these two struts may be judged from the deflections under small loads.

tests (1896) that the calculated eccentricity or curvature of one strut varied during the test from 0·001in at small loads up to 0·04in and at big loads it is calculated to be 0·28in. Similar results are reported in Bauschinger's and other test figures (ref. Table VII), so that it appears that the whole of the deflections may not be caused by the assumed imperfections in the strut or the loading, and it may, therefore, be quite natural for straight axially loaded struts within certain limits of slenderness to deflect a little before they buckle. Struts of this kind are here called "flexible" struts and the ratio of slenderness at which appreciable deflections before buckling cease to occur is called the "limit of flexibility" (ρ_0).

It is found from a simple energy calculation similar to those used above, using, however, a semi-empirical estimate of the effect of the axial shear (i.e. shear component of the axial strain), which appears to provide the restraining force, that the central deflection of an axially loaded strut with ends free or round, such as was used by Hodgkinson, would be approximately

$$\frac{1}{1 \cdot 4\pi} \cdot \frac{F_A \cdot s}{(P_Y - F_A)},$$

where s is the elastic shortening of the strut due to direct compression. Referring to Hodgkinson's tests[15] the average figures shown in Table V were obtained for 2½in solid round cast iron columns 10ft and 7ft 6in long, ends flat, showing the total shortening (s'), the shortening due to deflection ($s'' = \pi^2 y_0^2/4l$) and the shortening due to direct compression (s).

Thus the modulus of elasticity in compression was 3470 when the axial stress was 4·75 tons per square inch and 3350 at 8·25 tons per square inch, but from $f_a'' = 3\pi^2 E' . k^2/l^2$ E' is calculated to be 5800 tons per square inch and from bending tests on pieces of the same columns E'' varied from 6250 down to 3400 at rupture. In Table VI the axial shortening is calculated from $F_A . l/E.A.$ using $E=3400$ and the formula

$$y_0 = \frac{1}{1 \cdot 4\pi} \cdot \frac{l}{E.A} \cdot \frac{F_A^2}{(P_Y - F_A)} \quad . \quad . \quad (6)$$

It is found, however, that for smaller and thinner sections the assumed natural deflection depends on the thickness and profile of the cross-section, on elastic and physical properties additional to Young's Modulus, also on the relation of the slenderness ratio (ρ) to the limit of flexibility (ρ_0), so that the coefficient $1/1 \cdot 4\pi$ has, as an approximation, been replaced by the expression $\rho^2/\gamma\rho_0^2$, where γ is a non-dimensional coefficient to represent the properties of the member referred to above. When $E_{(axial)}$ is the same as $E_{(flexure)}$ the deflection would be

$$y_0 = \frac{l}{\gamma\rho_0^2} \cdot \frac{F_A^2}{P_Y(P_Y - F_A)} \quad . \quad . \quad (6a)$$

TABLE V—*Mean Values of* 35 *Tests on 2½in Solid Round C.I. Columns by Eaton Hodgkinson*

Length (*l*) ft in	*l*/*k*	Buckling load (F_A) tons	Load / Area tons/in²	Central deflection (y_0) inches	Shortening (inches) Total s'	Deflection s''	Compression s	Young's Modulus *E* (axial) tons/in²	*E'* (buckling) tons/in²	*E''* (bending) tons/in²
10 0	192	23·27	4·75	0·75	0·176	0·012	0·164	3470	5800	6250 initial
7 6	144	40·57	8·25	0·66	0·235	0·012	0·223	3350	5800	3400 at rupture

TABLE VI—*Tests on Solid Round Cast Iron Columns with Round Ends, by Eaton Hodgkinson*[15]

These columns were cut from the broken parts of 10ft columns, straightened and ends machined round. The axial shortening was not recorded and has been calculated from $E=3400$ tons per square inch.

Size and type of failure	Axial loads in tons (F_A)	Central deflection (y_0) inches: Test	Calculated: Formula below	Calculated: Perry	Buckling load (P_Y) estimated from the maximum load and deflection
Diameter, 2·553in Length, 59·5in *l*/*k*, 93 Area, 5·12 square inches End crushed at 0·73in diameter Broke at mid-length	21·8 23·9 26·0 28·1 29·2	0·04 0·07 0·12 0·26 0·6	0·04 0·07 0·115 0·265 0·66	0·05 0·08 0·126 0·27 0·59	P_Y assumed to be 30·2 tons. Perry formula: e assumed 0·016in in $y_0 = \frac{4}{\pi} \cdot \frac{e.F_A}{(P_Y - F_A)}$
Diameter, 2·546in Length, 59·5in *l*/*k*, 94 Area, 5·09 square inches End crushed at 0·6in diameter Broke at mid-length	23·9 26·0 28·1 29·2 30·3 31·3	0·05 0·07 0·1 0·13 0·18 0·26	0·044 0·07 0·1 0·13 0·19 0·28	0·05 0·07 0·106 0·135 0·18 0·256	P_Y assumed to be 34 tons. Perry formula: e assumed 0·0175in
Diameter, 2·546in Length, 59·5in *l*/*k*, 94 Area, 5·09 square inches Crushed at end and split. Broke at mid-length	26·0 30·3 32·3	0·14 0·22 0·3	0·038 0·075 0·106	0·13 0·22 0·295	P_Y assumed to be 40 tons. Perry formula: e assumed 0·055in

Deflection calculated from $y_0 = \frac{1}{1 \cdot 4\pi} \cdot \frac{l}{E.A} \cdot \frac{F_A^2}{(P_Y - F_A)}$.

The deflection in the last test may be due mainly to eccentric loading or to initial curvature.

and in Table VII Professor Karman's tests[16] on the deflection of axially loaded mild steel rectangular section bars are used to illustrate the use of this formula. The limit of flexibility is assumed to be $l/k=90$, which is a suitable value for mild steel bars of the section used and the coefficient γ is found by trial from the first series of deflections and then used for the other series, the value being 1·3.

Eaton Hodgkinson considered[17] that short columns fail partly by bending and partly by crushing and distortion of the material; also Professor W. J. Hoff[18] has recently shown that the mode of failure of long struts is different from that of shorter struts, which fail very suddenly. The departure from the Euler "phase" at the point where pre-buckling deflections do not occur is evidently explainable in this way. By deflecting slightly the axially loaded "flexible" strut avoids a combination of crushing and bending stresses and is thus able to carry more load than otherwise, but the "semi-flexible" column does not deflect under axial loading until it fails, so that it is unable to sustain the Euler load. It should be noted that the deflection of an axially loaded column does not always commence at small loads as does the deflection of eccentrically loaded or bent columns (compare Tables III and VII), and for this reason formula (6*a*) might not be theoretically quite correct. A formula of two terms, one representing the deflecting agent and a second the restraining force, would give this effect, but it is found that for small values the deflection becomes the difference of two much larger quantities, the second of which is mainly empirical, so that the results are unsatisfactory. The restraint on the deflection seems to arise out of the axial shear, which, being proportional to the axial load modified by the shape and thickness of the member, is, in a strut, most effective in thick sections. A rough approximation of the buckling load in the semi-flexible phase is given by $P_Y' = \sqrt{\frac{1}{2}F_C \cdot P_Y}$ where F_C is the crushing load of a short piece of the material of the same cross-section, or limit of proportion of a very ductile material, so the semi-flexible phase is a direct function of k/l.

It appears that the occurrence of the limit of flexibility in elastic columns depends on the properties of the material, the thickness and profile of the cross-section, and on the curve factor of the deflection, so that it may vary considerably for several reasons. Fig. 4 is based on tests made by Professor Robertson[7] on solid round cast iron struts of $\frac{21}{32}$in and $\frac{1}{2}$in diameter with ends freely hinged. There are two evident breaks in the column curve and the lower one coincides with the limit of proportion of the material in compression and apparently is due to the change in the elasticity as suggested by Professors Karman and Southwell (also ref.[2], Art. 103, page 301). The second break appears to be the limit of flexibility as modified by the reduced Young's Modulus, which at that point is 5200 tons per square inch, compared with 6300 tons per square inch initial modulus. Almost identical results were obtained by Professor Lilly[19] and other investigators.

TABLE VII—*Tests on Mild Steel Bars in Compression with Ends Freely Hinged, by Professor T. Karman*[16]

Size of bars	Axial loads, tons (F_A)	Central deflection (0·001in) Test	Central deflection (0·001in) Calculated (y_0)	Perry eccentricity e(0·001in)	Euler buckling load $P_Y=\pi^2E \cdot I_Y/l^2$
Breadth, 1·185in Thickness, 0·718in Length, 36·4in l/k, 175·5 Area, 0·85 square inch	2·23	0·35	0·32	0·18	P_Y=3·68 tons. Perry eccentricity in y_0 $=\frac{4}{\pi}\cdot\frac{e \cdot F_A}{(P_Y-F_A)}$ calculated from test figures and Euler load
	2·97	0·98	1·16	0·183	
	3·12	1·58	1·62	0·224	
	3·27	2·36	2·12	0·233	
	3·415	3·65	3·31	0·223	
	3·563	9·85	9·8	0·255	
Breadth, 1·185in Thickness, 0·713in Length, 30·1in l/k, 146 Area, 0·845 square inch	4·45	0·79	1·1	0·131	P_Y=5·39 tons
	4·75	1·97	2·4	0·208	
	5·05	4·33	3·7	0·23	
	5·2	9·48	7·5	0·273	
	5·344	33·9	34·3	0·23	
Breadth, 1·185in Thickness, 0·712in Length, 23·7in l/k, 116 Area, 0·845 square inch	7·73	0·79	1·15	0·08	P_Y=8·72 tons
	8·02	1·97	2·35	0·135	
	8·16	2·75	3·05	0·148	
	8·32	4·33	4·45	0·163	
	8·47	8·28	8·7	0·193	

Deflection calculated from $y_0=\frac{l}{\gamma \cdot \rho_0^2}\cdot\frac{F_A^2}{P_Y(P_Y-F_A)}$.

$E_{(axial)}$=13,800 tons per square inch assumed equal to $E_{(flexure)}$.

ρ_0 assumed to be 90 and γ=1·3.

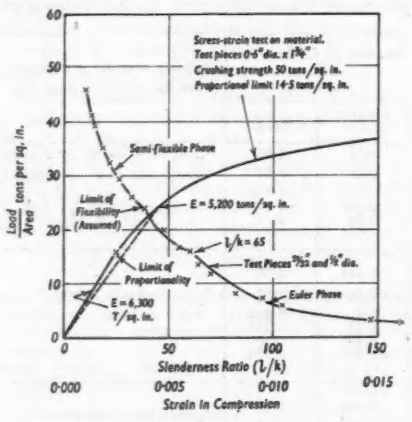


Fig. 4—Buckling of solid round cast iron bars with ends free

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(To be concluded)

F. W. Taylor, Engineer and Manager 1856-1915

By G. WILLIAMS, A.M.I.Mech.E.

THE historical sense is not highly developed in many engineers, so that often modern trends are unappreciated because the trends of developments in the past are not known. On March 21, 1956, occurred the centenary of the birth of Frederick W. Taylor, a great engineer and the world's first management consultant, whose life and work are worth study as they are illustrative of the peculiar difficulties facing engineers technically and in their dealings with others in industry. To this great American, engineers owe a tremendous debt for the phenomenal set of experiments in metal cutting which lasted twenty-five years, involving 40,000 separate experiments, and for the invention, with Maunsel White, of high-speed steel, yet these achievements were only made possible by Taylor's personality associated with a vigorous technical training. To-day, it is still true to say that technical training and academic distinction are insufficient for an engineer unless wedded to a personality suited to the situation.

Taylor came from well-to-do parents who were of Quaker origin. His early family life was certainly not narrow in a moral sense, yet it endowed him with a capacity to see the aspects of any problem as black and white rather than a series of greys, and he developed a persistence in attacking problems and a liking for experimentation which was with him even in his schooldays. He had intended to follow the profession of his father as a lawyer, but the course of study required at Exeter College affected his eyesight and he became an apprentice at the Enterprise Hydraulic Works in Germantown, Philadelphia, in 1874, at the age of eighteen. In 1878 he joined Midvale Steel Company as a labourer because there was no work available in his trade of pattern maker. He rapidly gained promotion to foreman of the machine shop, but in appraising this, two factors were present which probably ran counter to each other. Taylor was friendly with the owner's son, Clarence Clark (who married Taylor's sister), and who with Taylor won the doubles tennis championship of the U.S.A. in 1881, but, on the other hand,

the company was under the direction of William Sellers, who was described by Whitworth as the greatest mechanical engineer in the world and who would not tolerate a technically incompetent member of his staff. His superiors at Midvale provided that good-natured opposition which any intelligent man requires, and Taylor was soon taught that successful progress could only be based on a critical analysis of past and present practice by an incident which makes amusing reading. He became concerned with work on metal-cutting experiments (which Sellers had started earlier) and involved a new roughing tool which he showed to Sellers Bancroft, nephew of the owner, who said "Yes, that is a very good tool." "How do you know?" asked Taylor. "Well, I think we have been using it here for two years at least!" The metal-cutting experiments were only made possible by the support of Sellers, who ignored their cost and that they disrupted the work of the machine shop as the shafting speed of the whole shop was adjusted to suit the cutting speeds required by the experiments. The initial results after six months were negative and the experiments would probably have been abandoned, but for the persistence of Taylor. After two years, however, the experiments began to pay for themselves, one of the most important discoveries being that a heavy stream of water poured directly on the chip allowed an increase of cutting speed of 30 to 40 per cent to be made. Although the shops were open to competitors, nobody else appreciated this discovery and the first application of it outside Midvale was when Taylor went to the Bethlehem Steel Company in 1898.

Whilst at Midvale, Taylor began to evolve his system of scientific management, which must be reckoned his greatest contribution to industry. This system has too often been regarded as a series of techniques such as time study, but it represents an objective approach to management problems relying on an analysis of ascertainable facts and a recourse to experiment wherever possible. In this particular field, he became associated with Henry Gantt and Carl Barth, who were his assistants, but his views spread and a group including Gilbreth, Emerson and Towne gradually evolved to discuss management first within the A.S.M.E., but later, owing to the lack of sympathy of academic engineers, to form a society which became, after Taylor's death, the Taylor Society and later the Society for the Advancement of Management. In the field of management it is difficult to decide what are original contributions to the field other than in techniques, as otherwise one is dealing with philosophical concepts, and often slight differences in language hide similarities of approach. Taylor paid tribute to his contemporaries in the field in the U.S.A., but probably was ignorant of the views of the British pioneers such as Owen, Boulton and Watt and Charles Babbage. However, he succeeded in presenting his ideas (and others') in a coherent system for the first time and evolved such original techniques as standard instructions and time study (which has now developed and is known as work study).

Taylor left Midvale Steel Company in 1890 for a three-year contract as general manager of the Manufacturing Investment Company, and this period was an unhappy one for him. This unhappiness was concerned with the financial backers of the company having a different attitude from Sellers to Taylor's careful experimental approach which involved high first cost but which was ultimately worth while. Such a difference in approach is often found to-day by technical engineers who have a liking for applied research but who do not have the financial independence of Taylor, nor possibly his genius.

Taylor became the first consulting engineer in management in the world in 1893, and in work such as that at the Simonds Rolling Machine Company increased production by over 300 per cent. In this work he exhibited an attitude to human problems which is modern but which must have been revolutionary in those days. He reduced working hours on ball bearing inspection from ten to eight and a half hours per day, gave a half-day holiday on Saturday and four rest periods during the day—this was thirty years before the Hawthorne investigation. This advanced view seems to be inconsistent to some people with Taylor's experiment on "Schmidt" in loading pig iron at Bethlehem Steel Company, which he joined in 1898. The "Schmidt" experiment, in increasing the amount of pig iron shifted per day by each man from 12 tons to 47½ tons, exhibited an experimental approach to work physiology which is not out of date to-day. This experiment has been quoted as showing the inhuman aspect of scientific management, but such work was unusual and mechanical handling devices would have been employed in it normally by Taylor. Such a physical performance was only possible with selected personnel and "Schmidt" did not seem to have been any the worse for he was found in 1914 working ten to twelve hours per day and in good physical condition. At Bethlehem, Taylor developed fully his principle of functional foremanship, systems of production planning and cost accounting and invented high-speed steel with Maunsel White. This steel, which so astonished the British at the Paris Exhibition of 1900, did not represent such a fundamentally new departure in composition as in heat treatment. It was discovered by White and Taylor that if they soaked steels containing chromium and tungsten in the temperature range of 1500 deg. to 1725 deg. Fah., they were ruined, but above these temperatures and especially above 1850 deg. Fah., and near to the melting point, the best results were obtained. This invention saved Bethlehem Steel Company 1,000,000 dollars, but lawsuits ensued over the patent rights and Taylor did not greatly benefit financially.

In 1901 he and his associates were sacked upon Bethlehem Steel Company being sold, and at the age of forty-five Taylor retired to prosecute his own interests. These included gardening, and his experiments with growing grass for golf putting greens exhibited all the care and persistence in experimentation which distinguished his industrial experiments. He was elected President of the A.S.M.E. in 1906, being told afterwards "because the Society needs reorganising." This Taylor accomplished in the face of opposition from a body of College professors with whom he was not in general sympathy. His attitude to the contemporary academic training of engineers was shown in his address when made Hon.Sc.D. at the University of Pennsylvania in October, 1906; this address was entitled "A Comparison of University and Industrial Methods and Disciplines: being a Protest against the Excesses of the Elective System and Loose University Discipline and a Plea for Bringing Students Early into Close Contact with Men Working for Their Living."

Taylor, during his retirement, took to writing such papers as that on "The Art of Metal Cutting," which was delivered to the A.S.M.E. in 1906 and the books on "Shop Management" and "The Principles of Scientific Management." These books were useful, for Taylor to paraphrase in his evidence before the Congressional Committee which was appointed in 1911 to investigate the Taylor and other systems of management. The agitation which caused the appointment of this committee originated at Watertown Arsenal, but the precipitating cause was far different from the fundamental cause, which was a reaction to new ways of thought introduced into industry by Taylor. We are the heirs of Taylor, yet it is difficult to pay full tribute to him because so much of his contribution to the world is represented by new ways of thought. Taylor influenced strongly Hugo Munsterberg, who was the first industrial psychologist, and Jules Amar, who was one of the first in a line of European work physiologists. It is, however, to Taylor the specialist in metal cutting and the co-inventor of high-speed steel that we as engineers pay tribute on the centenary of his birth.

Birthday Honours

THE birthday of Her Majesty the Queen was officially celebrated on Thursday, May 31st. An Honours List, published on that day, includes names, as follows, of those engaged in or associated with the engineering profession :—

Viscount.—Baron Cherwell, C.H., lately Professor of Experimental Philosophy, Oxford.

Baron.—Lieut.-General Sir Ronald Weeks, K.C.B., chairman of Vickers, Ltd.

Knighthoods.—Mr. A. I. Anderson, for services to the British shipping industry; Dr. H. W. Clarke, chairman of the Aluminium Industry Council; Mr. G. H. Dowty, chairman of Dowty Group, Ltd.; Mr. H. S. Gibson, managing director, Iraq Petroleum Company, Ltd.; Professor W. J. Pugh, director, Geological Survey; Mr. A. S. Quartermaine, M.I.C.E., past-president, Institution of Civil Engineers; Mr. G. S. Summers, director, John Summers and Sons, Ltd.; Commander (S.) R. G. A. Jackson, chairman, Preparatory Commission, Volta River Project.

C.B.—Major-General G. O. Crawford, R.A.O.C.; Major-General W. G. Fryer, late R.E.; Mr. John Anderson, chief scientist, Admiralty Signal and Radar Establishment; Mr. A. E. H. Masters, director, Fighting Vehicles Research and Development Establishment.

C.M.G.—Mr. D. H. Black, chief scientific officer, Ministry of Supply.

G.B.E. — General Sir John Whiteley, Colonel Commandant, Royal Engineers.

K.B.E.—Major-General Harold Williams, R.E., formerly engineer-in-chief, Indian Army; Sir Thomas Merton, treasurer, Royal Society.

C.B.E.—Mr. R. P. Beddow, Mr. L. H. Bedford, Mr. Lewis Boddington, Captain E. Denman Clarke, Mr. R. Keith Craig, Mr. R. M. Currie, Mr. E. W. Ditchburn, Mr. J. R. V. Dolphin, Mr. L. N. Duguid, Brigadier Kenneth Hargreaves, Mr. Robert Kean, Mr. C. H. Leddra, Mr. A. B. Mann, Mr. J. D. Peattie, Mr. C. W. Scott, Lieut.-Colonel T. Eustace Smith, Dr. Charles Sykes, F.R.S.

A Visit to Harwell

THROUGHOUT last week the Atomic Energy Research Establishment at Harwell held Open Days to which were invited distinguished visitors, members of universities, and the lay and technical Press. Never before had the establishment opened its doors to so many people.

Judging by our experience, it cannot be said that anything particularly novel was on view. Yet it was a great pleasure to the guests of the establishment to see in the round so many of the reactors, instruments and other objects and devices which had before been familiar to them only as represented by photographs, drawings and descriptions in the Press. We make no apology, therefore, for presenting here only a brief and disjointed account and confining that account only to those departments which we visited. Nor do we intend to be deeply technical. For that would be to convey a wrong impression of what a visitor can expect to learn upon an Open Day. The intention of such days is to convey a general impression of the work going on and the equipment used rather than to enter into detail.

The Harwell Establishment, of course, bears much the same relationship to what is now rapidly becoming a nuclear engineering industry as any other research and development establishment bears to the industry it serves. It is not the job of those who work at Harwell to design and build full-scale power producing reactors such as those due very soon to come into operation at Calder Hall or under construction at Dounreay. It is their job to provide the fundamental physical and chemical knowledge, without which design could not be attempted, to gather knowledge in pilot plants of factors more closely related to engineering, such as the distribution of flux density and of temperature in a reactor, to study under fully controlled conditions the advantages and disadvantages of differing types of reactors; to gain comparative information about the qualities of differing coolants and moderators, and to study the effects of radiation upon metals and other materials. There are, in addition, large fields for study less closely related to actual power plant design which, though of less interest to engineers, are very important; the extraction of uranium from its ores, the separation from used nuclear fuel of the fission products and plutonium produced, the means of enriching U238 with U235, and the physics and chemistry of nuclear fuels and the various materials suitable for use as moderators, coolants and for structural and canning purposes. In addition, problems of waste disposal, of health, and in the use of isotopes must be studied.

Reactors

The actual task, of course, is that of developing reactors. This work is primarily done by the use of reactors of low power output specially designed to facilitate the carrying out of experiments upon one or more particular facets of reactor design or operation. Reactor "Gleep," for example, the first nuclear reactor to be built in Europe, is designed to run at power outputs up to only 100kW. It employs a natural uranium/uranium oxide/graphite system and needs no elaborate cooling arrangements. Its prime purpose is that of materials testing and it also provides a source of slow reactions for exponential and biological experiments. The output of reactor "Zeus," illustrated in Fig. 1, is even smaller. It runs at a power of less than 100W and needs no provision at all for cooling the core. This is a fast reactor with an enriched uranium core and it is a low energy version of the 60MW fast reactor to be built at Dounreay. At Dounreay sodium is to be used as the coolant. In "Zeus" this material is replaced by the aluminium and magnesium hexagonal rods to be seen in the picture, surrounding the core tubes. Any of these rods can be removed for the insertion of instruments or materials whose behaviour is to be studied. "Dimple," a low power thermal neutron reactor moderated by heavy water contained in a tank surrounded by a graphite reflector, is designed to permit rapid changes of the type of fuel and in its arrangement so that the performances of what are in effect different designs of reactor can be quickly studied. In particular, it has been used as a pilot model for the design of "Dido," which is now approaching completion and which is to be used as a materials testing reactor. It is to have a high intensity neutron flux of 10^{14} neutrons per square centimetre per second and will be a heavy-water cooled and moderated reactor with a heat output of 10,000kW. The core will consist of highly enriched uranium alloyed with aluminium. Besides permitting radiation damage to be studied, high specific activity isotopes for medical and industrial use will be produced

Fig. 1—Reactor "Zeus," here seen opened for inspection, has an output of only 100W. It is a fast reactor with an enriched uranium core and is a low energy version of the 60MW Dounreay reactor. The sodium coolant to be used at Dounreay is replaced by aluminium and magnesium rods

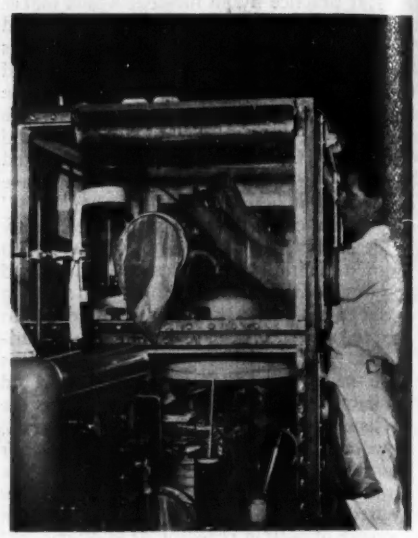


Fig. 2—Use of a sealed glass box is seen here. This form of box can be used, for example, for handling plutonium where the hazard to be guarded against is that of α radiation. The "posting box" and container for removing or inserting materials into the box can be clearly seen

and facilities will be available for research in neutron physics and radiation chemistry. By contrast, "Pluto," a reactor scheduled for completion in mid-1957 and apparently very similar to "Dido," having an identical heat output and neutron flux, being heavy-water cooled and moderated and utilising the same core material, is to be used for irradiating future reactor fuel elements and to check heat transfer, corrosion, mass transfer, radiation damage, radiation decomposition and fluid fuel chemistry. A third reactor under construction is "Lido." This, like "Zeus," will develop so low a power that elaborate cooling is unnecessary. It is to be of the swimming-pool type, using enriched uranium solid fuel and moderated by demineralised light water. The output will be about 100kW at a neutron flux of 10^{12} neutrons per square centimetre per second. Large aluminium panels in the tank provide access for testing shielding. Then there is a core tank which sits inside a larger reflector tank. Uranium can be loaded into the tank, which is filled with natural water, and neutron fluxes can be measured as assembly proceeds. The purpose of such experiments is to determine the sizes of the various arrays at which a self-sustaining chain reaction may be maintained. Lastly, there is the eight-year-old "Bepo" generating 6·5MW, whose primary purpose, we imagine, is likely soon to become that of radioactive isotope production, the more specialised plant already mentioned being better suited for many of the purposes for which "Bepo" has been used.

Isotopes

Mention of isotopes reminds us that Harwell is still by far the largest producer in Europe of these materials and that much research is conducted there into their uses. Particular interest is taken in those particular isotopes that are produced as a by-product of power generation as a consequence of the contamination of nuclear fuel with fission products. After separation these products have to be disposed of. Most of them have relatively short radioactive half-lives so that, supposing that no use can be found for them, disposal presents only a short-time storage

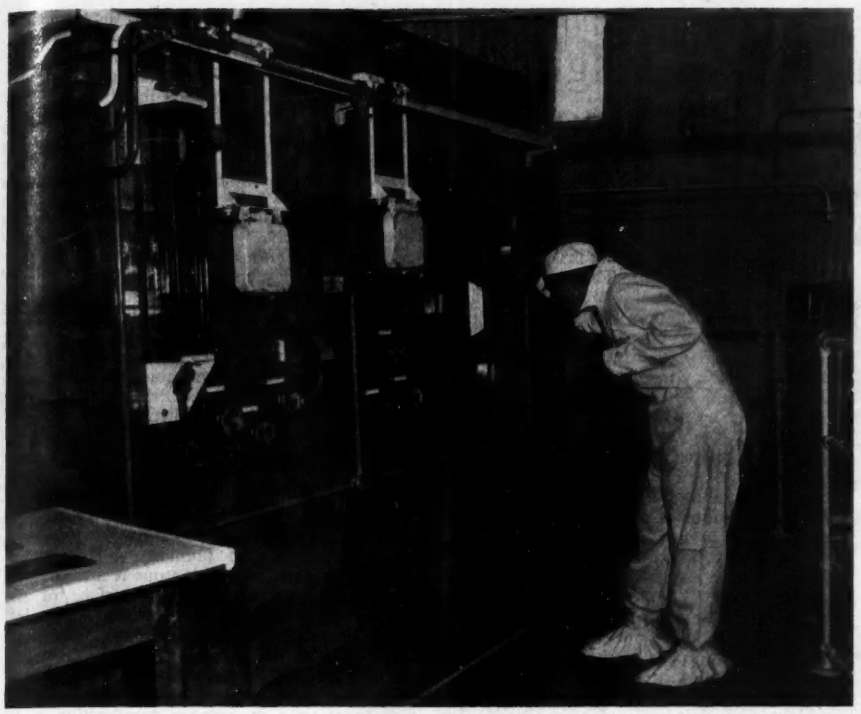


Fig. 3—Where radiation hazards are high and a screen has to be interposed between the material and the operator, tongs of the type here illustrated can be used

problem to allow the radioactivity to decay to a safe level. But two fission products, caesium 137 and srontium 90 have very long half-lives. The first emits gamma rays and has a half-life of thirty-three years, the second is a beta emitter with a half-life of twenty years. It would, therefore, be very convenient if uses could be found for these materials ; and uses are being found. Irradiation of foods can bring about sterilisation, facilitating food storage, and the irradiation of materials, more particularly plastics, can bring about interesting and useful changes in their properties. But whether demand will ever equal the prospective supply of these materials is very much another matter.

Plutonium

More directly in the line leading to the development and improvement of reactors is the work being done on plutonium, a material produced artificially by the irradiation of uranium in the cores of reactors. This metal has peculiar properties. In particular, there is connected with it a special alpha hazard and great care has to be exercised in working upon it lest any of its dust be ingested into the lungs or absorbed through an injury to the skin. It is, therefore, handled only in ways that prevent its dust reaching the human body. Visitors were able to see work being done in special glass walled and slightly evacuated boxes, having apertures through which the hands can be inserted into long rubber gloves—Fig. 2—sealed at their edges to the boxes. Within such boxes all the ordinary chemical and physical procedures of a laboratory can be carried out. Ingenious methods have been worked out for introducing equipment into the box or taking them out without breaking the seal. To remove an object, for example, it is " posted " by the rubber-covered hands into a polythene bag hanging down from an aperture in the box. Since this object will be contaminated it must remain sealed up after removal. That object is achieved by the simple means of sealing off the end of the bag containing the object, by the use of an electrically heated strip sealing press. A parallel seal is made in the bag closer to the box and the end cut off between the two seals.

It is remarkable how much work can be done in a sealed box. One of the demonstrations that visitors saw was, for example, the use of a lathe. But there are necessarily limitations. If an operator has, therefore, to work in a room containing the dust hazard, he has to wear a form of " diving " suit such as that illustrated in Fig. 4. Air is supplied through a pipe and there is telephonic communication with the area outside the room. On emergence from the room —through an air lock—the suit has to be washed down with water before the wearer discards it.

Visitors were able, protected by a rubber glove, to feel the weight of a block of plutonium ; and to feel also how very warm it was as a consequence of its radioactivity.

Remote Handling

This description of means of handling plutonium leads on naturally to the subject of remote handling in general. The glove-box technique can be used only when the hazard is that of alpha emitting dust. For more intensive radioactive hazards and other forms of emission, some form of shielding must be interposed between the operator and the material to be handled. Various remote handling devices were demonstrated to visitors, many of them designed and made at Harwell. All have been the subject of illustration and description in the Press. But it was a pleasure to visitors to be able to handle them. For the majority of purposes the principle is that of mounting a tube in a ball joint in such a way that it can slide in and out and be rotated (Fig. 3). A pistol grip handle with a " trigger " lever permits the tube to be manipulated and also actuates a rod within the tube. Vision into the chamber is obtained through apertures fitted with heavily leaded glass. Where objects to be handled are heavy and the ball-joint is consequently large, friction can be overcome by floating the ball on compressed air. Even this method of operation becomes impossible where the hazards are extra high and when the tube itself may become contaminated. An " over-the-wall " type of mechanism has then to be used. In such a device long levers hang down before the operation from above and are mechanically linked to similar levers on the far side of the shield. The mechanical connection is such that every movement of the operator's hands, up or down, in or out, or rotatory, is copied by the ends of the levers within, and a gripping action on the controls causes tongs at the heads of the levers within to close. Two difficulties have to be overcome by practice. There is no sense of touch in picking up objects with the tongs, so that the degree of pressure to use has to be learnt ; and the tongs and objects all being several feet away and behind, for example, a zinc-bromide viewing window, the judgment of distance has to be acquired.

Chemical Processing

As has already been remarked, nuclear fuel in use becomes contaminated with fission products. From time to time these products must be extracted. Some idea of the nature of the problem can be gained from the fact that every ton of rods discharged from atomic piles contains about 1 lb of plutonium, and about the same weight of radioactive fission products. All these products have to be removed in spite of the fact that the material is so radioactive that no human operator can be allowed near it. The present process used at Windscale has disadvantages that it is hoped may be overcome by the substitution of another now being studied at Harwell. At Windscale the rods are dissolved in nitric acid and the fission products and plutonium extracted by solvent-extraction processes. The purified uranium comes out as a salt in solution and has to be reprocessed back into the metallic form. By the process now being studied at Harwell this somewhat roundabout method would be avoided. Instead the uranium would be purified by melting in a furnace, some 40 per cent of fission products, including caesium and strontium, being emitted as gases, to be separated out by condensation and the extraction of others in the slag. Present knowledge suggests that not all the radioactive products could be removed in this way ; so that a disadvantage of the process would be that at all stages it would need to be conducted behind shielding.

An alternative method of dealing with the situation arises if the uranium fuel can be used in liquid form. If the temperature were high enough some of the fission products would be created in gaseous form and solid contaminants

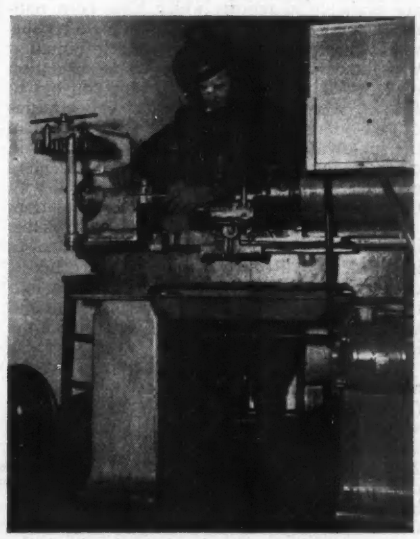


Fig. 4—When the work is of such a character that it cannot conveniently be done in a glove box the operator must wear such a suit as this with an external air supply and telephonic communication

could be filtered out, all in a continuous process. That is easy enough to conceive. It is far more difficult to carry out. The study of the possibilities has led Harwell workers to advanced studies in the operation of hydraulic cyclones, gas separation and particle size analysis.

Conclusion

It will be observed that in the course of a single day visitors were shown a variety of exhibits. Nor within the confines of this article have we been able to mention all that was seen. Yet no more than a fraction of all that is going on could be shown in the time available to any individual visitor. We hope, now that the ice has been broken, that the Harwell establishment will regularly, each year, like many other research laboratories, hold such Open Days.

Influence of Insulation Design on Condensation and Corrosion

The following article is based on a lecture given by Mr. N. L. Dolbey before the Indoor Section of the Atmospheric Corrosion Sub-Committee of the British Iron and Steel Research Association.

CASES of corrosion of metal coated on its inner surface with insulating materials are frequently encountered, particularly where the insulation has become damp. Since this problem first arose acutely, shortly after the introduction in this country of the first all-steel railway carriages some twenty-five years ago, many attempts have been made to overcome the trouble. For a long time the mechanism of this kind of corrosion was in doubt. Some thought that the materials used, especially asbestos, were the prime cause. Various attempts were made to use non-absorbent insulants or to waterproof the visible face of the insulation with a film of bitumen or the like.

In an effort to avoid those insulating materials which were showing corrosion-promoting tendencies, many tests were carried out with various samples by exposing them to the atmosphere. It was noted that certain chemically inert forms actually tended to prevent corrosion of the metal base, while other forms—and these the more usual ones—gave rise to heavy rusting.

A series of exposure trials was begun in 1940 by the Protective Coatings Sub-Committee of the Corrosion Committee of B.I.S.R.A. As part of these tests, which were conducted at Sheffield and at Llanwrtyd Wells, steel plates covered by coatings which had shown anti-corrosive properties were exposed to the atmosphere and later examined. The results have been tabulated and are available in reports which have been published since by B.I.S.R.A. Some time after this work had begun, much valuable information was gained from the performance of insulation on H.M. ships engaged in escorting convoys to Russia, where the low external temperatures caused hundreds of tons of ice to condense in the sub-divided air spaces used for insulation in crews' living quarters. There remained, however, many unexplained matters connected with the overdrawing and decoration of the insulation.

Because of this and the lack of any reliable information about the fundamental processes involved, J. W. Roberts, Ltd., of Armley, Leeds, decided to set out a research programme into the causes of condensation on the one hand and the formation and movement of water inside the insulation on the other.

Water vapour is present in the air in varying amounts, from 0·2 to 5 per cent by weight (28–700 grains per cubic yard), an important source being evaporation off the ground, which in this country takes place at an average rate of 2 oz of water per square foot per day. The diffusion of vapour in a still atmosphere, e.g. inside a layer of porous insulation, is proportional to the gradient of the partial pressure. In the case of metal insulated on one side being exposed on its air face to low temperatures, the interface between metal and insulation frequently drops in temperature to below the dewpoint. The resulting condensation is replenished by further diffusion from the air inside the insulated space. Reference to vapour pressure-temperature graphs show that (for instance) the vapour pressure at a steel surface at 35 deg. Fah. and 80 per cent relative humidity is 4·2mm of mercury. With an internal air temperature of 65 deg. Fah. and relative humidity of 60 per cent, it is 9·6mm of mercury. The dewpoint of air at 65 deg. Fah. and 60 per cent relative humidity is 51 deg. Fah. The interface will be at a temperature between outside and inside, say, 42 deg. Fah., at which temperature the pressure of saturated vapour is 6·9mm of mercury, giving a difference of 2·7mm of mercury to drive the water vapour through the insulation towards the metal, where it collects and can cause corrosion. The effect is all the more serious as the insulation-covered surface cannot normally be repainted.

The movement of water thus takes place in the form of vapour which only inside the insulation is turned into liquid. This explains why it is useless, and in fact harmful, to specify a so-called " water-proof " insulation, which usually means one which is water repellent, because such a water repellent but vapour permeable layer makes it difficult for the condensate water to get out again. The same applies to the painting of the insulation with water-proof (but not vapour-proof) paint. The result is that water accumulates and appreciably increases the weight of the insulation, quite apart from questions of corrosion and increase in thermal conductivity.

With those kinds of insulation which fit the metal completely and without air gaps, the moisture tends to build up within the insulation itself. When the insulation rests merely on high spots condensate is able to collect in the air gaps and if unable to escape can lead to fissure corrosion, especially when soluble sulphides are present in the coating (which, incidentally, can easily be detected by immersing a sample of the insulation in dilute hydrochloric acid). Insulations bonded with silicate of soda should also be avoided as this is an efficient paint stripper.

If the insulation is applied in such a way as to leave air spaces between it and the metal surface, water vapour will pass through without condensing, but will then condense on the metal. In the case of roofs it will drip back on the insulation, while in the case of side walls the condensate will run down the walls and accumulate at horizontal ledges in much the same way as when no insulation is used, though more often, thus causing increased corrosion at these points.

Vapour barriers have been advocated as a means of avoiding build-up of water in insulation applied over metal surfaces, but it must be realised that in such cases they can only retard, and not entirely stop, the ingress of water vapour. (They should always be applied to the warm surface of the insulation.) Their permeability factors are usually known and quoted for 1in thickness, but in order to be reasonably effective they must be free from punctures and leaky joints, as water vapour, like any gas under pressure, follows the path of least resistance. It is far more difficult in practice to achieve this continuity of vapour barrier than any laboratory experience may suggest. Since all such barriers are waterproof, flaws in the vapour barrier will lead to a growing weight of water being trapped in the insulation for a longer time, which, from the point of view of corrosion, makes matters worse.

It is thus a question of preventing water in the insulation from accumulating. By selecting a material with good wicking or capillary properties, and applying it directly to the metal surface, one is able to remove water from the steel surface back to the opposite side as fast as it condenses. With the insulation thick enough to ensure that the inner face is above the dewpoint the condensed water is re-evaporated if there is sufficient air circulation. The rate of re-evaporation depends upon a number of other factors besides air speed and surface temperature ; the degree of saturation deficiency will affect it, and also the texture of the surface. A smooth surface, by permitting a better scavenging, will give more evaporation than a rough or granular surface, other things being equal. As to the efficiency of this process, investigations have shown that the amount of water capable of being withdrawn by a wick $\frac{1}{8}$in in diameter is some 650 times greater than the maximum weight of water vapour that can pass in the same time through a clear $\frac{1}{16}$in diameter hole under the highest vapour pressure difference likely to be encountered in practice.

Asbestos fibres have excellent wicking properties because, being bundles of finer fibres with an ultimately molecular diameter, they will draw out water parallel to the fibre structure, without releasing it to the interstices produced when the fibres are formed into an insulating felt. It has been found in this connection that blue asbestos, or Crocidolite fibre, which has recently come to the fore in the manufacture of asbestos cement pipes because of the way in which it assists manufacture by the removal of water, has a higher capillarity than white asbestos, from which it will withdraw water, whereas the reverse does not apply. By incorporating suitable corrosion inhibitors with asbestos felt it is possible to apply coatings which keep dry and have a definite anti-corrosive value.

In crews' living spaces on ships, where it is usual to apply insulation directly to the inner surface of the metal plates and to cover it with a hard wearing layer of permeable asbestos cement trowelled on, it is observed that such insulation will remain dry and that there is very little, if any, corrosion after many years, provided the porous cement surface is not coated with water-proof paint or overdrawn with panelling. The effect of panelling is to produce a restricted air space over the warm face of the insulation, and by lowering the air temperature in this space increase the relative humidity. This makes re-evaporation difficult, or stops it altogether if the temperature of the inner surface of the insulation is decreased below the dewpoint. It is, therefore, not surprising to find during winter months that even good quality insulation, when overdrawn with panelling (as in railway carriages) is often wet. An even worse method sometimes used in carriage construction is to stuff the space between steel and panelling completely with insulation, thus preventing any circulation of air, without retarding to any extent the penetration of water vapour. In North America, where this system has been used extensively, it is quite common to find at the end of the winter that the insulation is a solid block of ice.

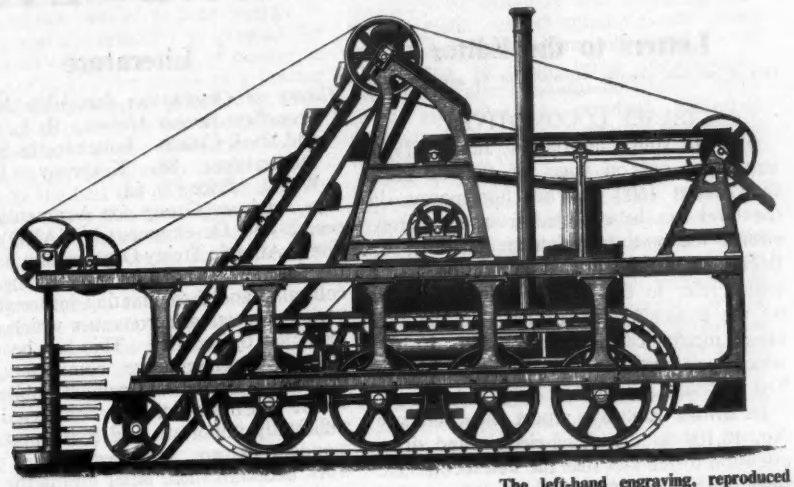
Of course, when the outer metal is exposed to temperatures below freezing point, the vapour will freeze and capillarity will not be able to remove the ice which is formed. A technique developed more recently for dealing with this problem is to use a vapour barrier incorporating wicks, so that vapour penetration during freezing conditions is retarded, but re-evaporation after thawing is not interfered with. The layout of heating and ventilating arrangements employed also affects the question of moisture content and corrosion. Quantitative studies are still in progress, but it can already be said that it is bad practice to circulate so-called " dry " outside air over the insulation. The relative humidity of such air is frequently over 80 per cent, which in combination with a low temperature, can cool the warm face of the insulation below the dewpoint. It is only necessary to circulate the warm inside air which, being warm, has a much greater saturation deficiency and keeps the inner face of the insulation above the dewpoint.

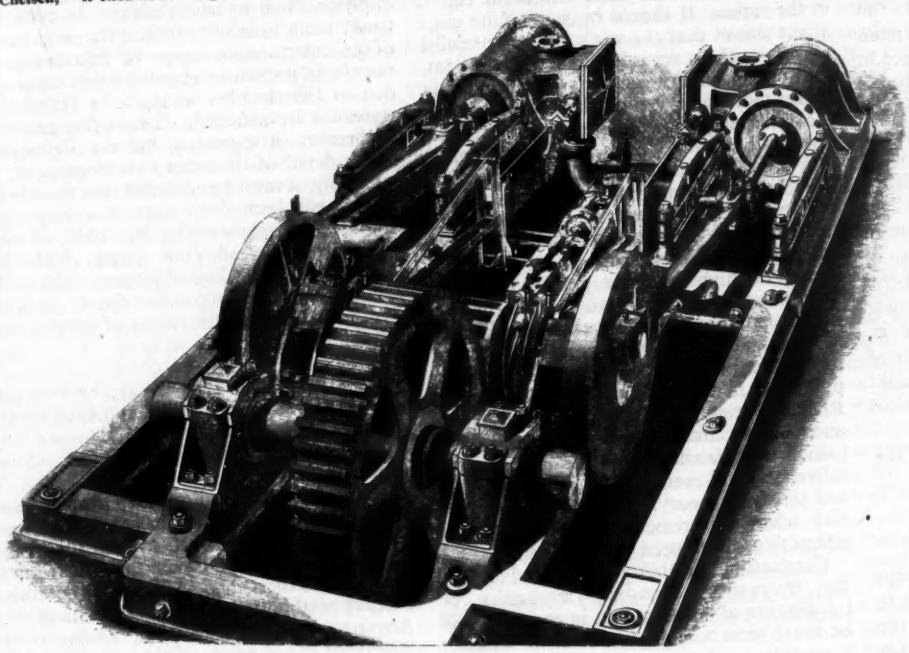
As far as the design of inner panelling is concerned, this should never be fastened to continuous flush frames. Part of the heat from the heating system should be allowed to pass behind the side panelling, e.g. by locating the heating pipes partly inside the panelling at floor level.

IMPROVEMENT SCHEME AT GARSTON DOCKS.—The Docks Division of the British Transport Commission is to spend £275,000 on improvement works at Garston Docks, on the Mersey. At Stalbridge Dock, which is the largest of the three docks at Garston, the 775ft long south-east quay is to be lengthened to 1000ft. This quay is used by vessels discharging timber, pit props, chemicals, fertilisers and other bulk goods, trades for which tramp vessels of 10,000 to 12,000 tons deadweight, with lengths of 420ft to 450ft, are increasingly being used. The work will allow two modern tramp vessels of this kind to berth at the quay. A crane track and sidings are to be provided, and two 3/6-ton electric level luffing cranes installed, in addition to the eight cranes to be delivered from July of this year. At North Dock, electrically-operated steel gates are to replace the timber gates, now over eighty years old, which protect the 55ft entrance to the dock. Five coal tipplers are to be reconstructed.

ENGRAVINGS OF 1869

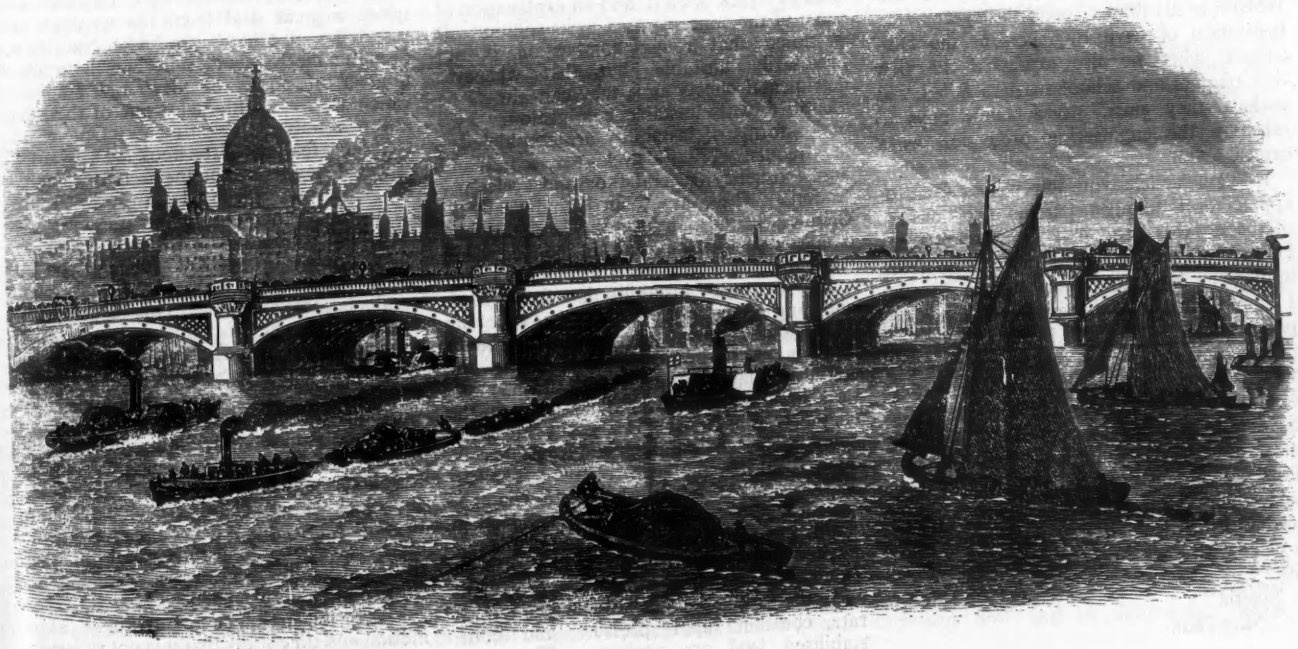
Vandenvinne's steam excavator, which is illustrated by the right-hand engraving, was described in our issue of December 31, 1869. "Excavating and embanking," we said, "is a perpetually recurring operation in all works of engineering and construction generally. The making up of embankments is simply a work of time; it is in the excavation that the navvy has to put forth his bone and muscle; it is by digging that the necessary material for the bank is obtained." Our article goes on to say that "in early times digging was the last resource for men who had no other means of gaining a livelihood but by manual labour, and it cannot, therefore, be regarded as a gentlemanly pursuit." Vandenvinne, we then said, had invented "a machine for excavating earth which promises to be of great value and practical utility." The description continues: "It is a steam engine as well as an excavating machine, and combines the motive power and the excavating agent all in one." The whole principle of the apparatus was that "the earth is excavated by a double series of horizontal picks rotating in opposite directions, which literally claw away the earth in front of them as the machine advances. These picks are in the form of a shovel, and as they dig out the earth horizontally it is thrown back and falls into buckets fixed on an endless chain." When we witnessed its performance at Chelsea, "it excavated the ground to a depth of 2½ft."





The left-hand engraving, reproduced from our issue of October 29, 1869, illustrates the "fine reversing rolling mill engines," constructed by Thwaites and Carbutt, Bradford. The engines, it was stated, were of "140 nominal horse-power (collectively), the cylinders being 35in diameter and 4ft stroke." "The valve gear of both engines," the description reads, "is reversed by means of a small steam cylinder operating upon a weigh-bar shaft."

On November 5, 1869, we published the engraving, which is reproduced below, of the New Bridge, Blackfriars. "To-morrow," we wrote, "should no unforeseen event interpose, it will be honoured with a royal inauguration." We noted that "the prospect of a state visit from the Queen has been sufficient to put the civic authorities into a flutter of anticipation." We also pointed out that the occasion was one in which a civic pageant properly meets with reference in the columns of a scientific journal! To that we added: "we have endeavoured to contribute our quota to the demonstration by laying before our readers representations of the new Blackfriars Bridge, a structure which, as a work of art and a specimen of engineering, deserves more than ordinary praise, serving nobly as a highway by which the Queen of England may cross the Thames into the citadel of her empire."



LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

DIESEL LOCOMOTIVES

SIR,—In your Editorial for June 1, 1956, you point out on page 586 that no more than about 1600 drawbar horsepower on the level can be expected from the diesel-electric locomotives which are on order by British Railways. In this connection may I please refer to the British Railways report on the dynamometer car tests on the Fell diesel mechanical locomotive No. 10,100, which you wrote about on page 140 of THE ENGINEER for January 27th.

In British Railways report they compare No. 10,100 to the diesel-electric and draw attention to the fact that the Fell locomotive sustained a drawbar horsepower at full throttle of 1900. It is true that this maximum horsepower was developed at 44 m.p.h. and not at 60 m.p.h., but this lower speed is peculiar to No. 10,100 and on projected applications of this transmission system using the same main engines, a drawbar horsepower of 2000 at 60 m.p.h. will be available.

The comments by British Railways in their dynamometer car report give two of the reasons why this system of transmission makes possible a higher drawbar horsepower than the diesel-electric system. There is, however, a third, namely, that the ratio of prime mover weight to transmission weight is more favourable with this mechanical system than with the electric drive.

L. F. R. FELL

London, E.C.2.
June 4th.

BOYS AND CAREERS

SIR,—Your leader under the title "Boys and Careers" in THE ENGINEER of April 6, 1956, struck truly at one aspect of the failure of our islands to produce an adequacy of engineers in these days. As did Mr. Watson in his dinner speech last year at the Institution of Civil Engineers at the Dorchester, when he also expressed the view that parents and school masters failed "as perhaps they must," to persuade boys to take up the engineering profession as a career.

In your article you imply that lack of appreciation amongst parents and masters of the rewards and opportunities that technology offers has prevented them from influencing boys to pursue such a career; I submit, sir, it is less than fair to single out parents and masters for blame, because as public appreciation is in our isles at present; to what extent comparable with the public weal have "Honours" gone to the men who have "directed the great sources of power in nature for the use and convenience of man." Lord Kelvin and Lord Armstrong did indeed serve their country well; are there not alive to-day British technologists who have earned a place with their "peers" in other walks of life?

"ENVIOUS"

Nigeria,
May 28th.

Literature

Theory of Combustion Instability in Liquid Propellant Rocket Motors. By L. CROCCO and SIN-I. CHENG. Butterworths Scientific Publications, 88, Kingsway, London, W.C.2. Price 37s. 6d.

THE Advisory Group for Aeronautical Research and Development (AGARD) of the North Atlantic Treaty Organisation has, over the past few years, been actively engaged in collecting and disseminating information on various aspects of aeronautics which are not restricted by security. This has been done through representative committees, conferences, symposia and printed publications. Where the information is considered to be sufficiently important and it is appropriate, monographs are produced. The present work is one of these latter and is the eighth in the series. It should be made quite clear at the outset that the work is of a specialist nature, both as regards the subject of combustion instability and its occurrence in rocket motors. It is possible that some of the theory developed could be adapted, with suitable modifications, to air swallowing engines and there is no doubt that those interested in combustion instability in any form of engine will find something of value in the book. It might, in fact, be well worth extending the rocket treatment to other forms of high intensity continuous combustion systems. The two authors have a high reputation for their studies on this subject, and much of their work has appeared during the past four or five years in papers published in the Journal of the American Rocket Society. This book collects these and other contributions to the subject (which are detailed in a valuable list of references) and moulds them into a coherent and satisfying theory. This has been no easy task when it is remembered that so many interacting phenomena are involved.

Combustion instability may be induced by the hydraulics, acoustics, mechanics or combustion of a system, but in general it will be due to some combination of them. Chapter 1 provides a statement of the problem, the lines of attack upon it, and an explanation of some of the concepts used in its solution. It is noted that rough combustion is not necessarily unstable, but that whenever detrimental effects arise they can always be identified with unstable combustion. Two major forms of instability are considered—low frequency (50–100 cycles per second) and high frequency (several thousand cycles per second). These are treated analytically in Chapters 2 and 3 respectively and the final chapter discusses the results of the theory and compares them with experimental data.

Low-frequency instability is referred to as chugging and occurs when the time lag between the propagation of a disturbance and its effect becoming apparent in the chamber is large compared with the propagation time of the disturbance through the chamber. The time lag is basically due to the delay in combustion after the propellants are injected and to the effect on the propellant feed system of a disturbance in chamber pressure. Both conditions are examined in detail, but the major part of the chapter is devoted to the propellant system aspect. This is first considered for a monopropellant and the special cases of constant feed rate, constant supply pressure, and servo-stabilised feed are analysed. The more difficult case of bi-propellant rockets (which introduce the additional variable of mixture ratio) is then considered, followed by some refinements to the analysis to allow for the effects of non-uniformity of time lag and temperature variation caused by the pressure oscillations.

High-frequency instability or screaming is more complicated because it is no longer possible to neglect the disturbing wave propagation time. Both time and space lags must be considered. This problem has been approached first by the simplifying assumption of combustion concentrated in one axial plane and later by formulations for distributed combustion. The predictions based on this analysis are later shown to be in good agreement with observed experimental data and so some confidence may be gained in applying them to new designs. In addition to the main instability ranges, the occurrence of an intermediate range of frequencies is noted and previous suggestions that these are due to the chamber acting as a Helmholtz resonator are criticised. A more fundamental mechanism is suggested, but not developed in the detail of the other two frequencies.

Finally, it must be recorded that the whole subject has been dealt with in a very able manner, the mathematics has been set out clearly and in adequate detail, and the arguments follow a logical pattern. The book can be thoroughly recommended to all who wish to understand the theory of combustion instability.

Motion Study and Time Study, by GERALD NADLER. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 56s. 6d.

DR. NADLER is Head of Department and Professor of Industrial Engineering, Washington University, St. Louis, Missouri, and he has now conformed with the convention that holders of such positions must produce a heavy textbook on motion and time study. Anyone writing such a book to-day must inevitably cover much of the ground which many previous writers have covered and quote a great deal from the writings and researches of others. Professor Nadler has been unable to avoid this, but there are a number of points of view and emphases which are fresh, although some of them will not win universal agreement. One of the refreshing features of the book is Dr. Nadler's repeated emphasis upon the need for research. He is always prepared to make a free admission of the limits of our present knowledge and is usually careful not to claim too much, reserving his final conclusions for some future time when sound research results become available. This very desirable attitude, however, has some unfortunate consequences. It has caused Professor Nadler to scatter through the book brief descriptions of statistical methods for studying the reliability and accuracy of motion and time study techniques. These descriptions seem to say too little or too much. They are formidable enough to frighten off the non-statistical, without giving enough explanation to help those who are prepared to try to understand. In any future edition these sections should be critically examined and either omitted or extended.

There is so much controversy about motion and time study that it is not surprising that many of Dr. Nadler's views are contro-

versial. We, for example, would question whether it is necessary to use the many varieties of process chart which Dr. Nadler recommends, especially as the same symbol means different things on different types of chart. Again, it seems that Dr. Nadler may be wide of the mark in suggesting that "the therblig chart is a rather special type of chart made only for certain situations." This is a common misconception, but it is surprising to find it here. Experience has shown that therbligs can help in the analysis of all types of work and that it is fallacious to regard them only as short basic elements of hand work. Another matter in which Dr. Nadler's views will not be widely approved is his trenchant criticism of predetermined time systems.

Perhaps the most useful and interesting part of the book is the discussion of rating, which, in Dr. Nadler's view, should be based upon pace and difficulty. Following Mundel, he regards pace as depending upon acceleration and deceleration of the motions of the body members. He also gives a table of eight correction factors for difficulty, also based upon Mundel's researches. He appreciates that the assessment of acceleration and deceleration is extremely fallible and suggests the use of a standard "step-film" showing various rates of work, to be projected (as a basis for rating) alongside the job being studied. He goes on to describe his research and development work upon an electronic device, the Universal Operator Performance Analyser and Recorder (UNOPAR) which he hopes will achieve a new level of objectivity not only in rating but in other work study techniques where accurate measurement of fine movements is required. He recognises that this device will be more costly to use than present-day methods of rating by subjective estimates. It remains to be seen whether it will prove economically worth while in the factory, but it certainly seems to have great potentialities for research.

The research approach, the statistical methods and Professor Nadler's comprehensive discussion of the many different techniques and theories which at present jostle one another in the work study field, make this more of a college textbook than a practical man's guide. For the student it is likely to prove highly valuable; for the practical work study man it is likely to be most useful as a work of reference in which to look up any well-known technique, together with Professor Nadler's (usually critical) comments.

Peaceful Uses of Atomic Energy: Vol. 3, *Power Reactors.* United Nations Publication, Sales and Circulation Section, Department of Public Information, United Nations, New York, U.S.A. Price 54s.

THE International Conference on the Peaceful Uses of Atomic Energy, held at Geneva last year, marked a point in the history of nuclear power development. The proceedings of this conference are now being published by the United Nations in a series of sixteen volumes. The first of these volumes to be issued set a very high standard. They are admirably produced, well laid out and have very clear diagrams. The scientific secretaries have in fact done an excellent job. In this third volume of the series are grouped the papers that were given in the sessions devoted to Power Reactors. The layout of the book largely follows the appropriate conference sessions. The sections cover Fuel Cycles, Experience with Nuclear Power Plants, Design of Reactors for Power Production and Prototype Power Reactors, with records of the discussions held during each session. To the engineer this is a most interesting volume. The wide variety of reactors that are here described underlines the vastness of the field within which nuclear energy is developing and the difficulty of gauging the relative merits of any one kind of reactor as a power producer. The choice of a reactor cannot even be considered in isolation without reference to other reactors which may be built. The cost of power production will be influenced by the overall costs of fuel cycling, and to make the best use of fissile and fertile material it is likely that more than one type of reactor will be part of such a cycle. Hence the interest of the papers on fuel cycles. It will be noted that in none of these papers is the author certain of the way developments will eventually proceed. Nuclear data are still not sufficiently complete, nor will the answers to many of the economic and technical problems be solved until more prototype and experimental reactors have been built. Dr. Weinberg, of the Oak Ridge National Laboratory, gives a good picture of the situation when he concludes by stating: "In any event certainly two nuclear types, the slow cycle based on U233-Th and the fast cycle based on Pu239-U will become accepted reactor types. Beyond this—whether the reactors will be homogeneous or heterogeneous, whether the moderator ultimately will be heavy water, beryllium or graphite, &c., what the coolant will be—these are difficult issues whose outcome no one can foresee." This book will form an extremely interesting historical document. The reactors described are some of those which at present appear most promising for development. A few of them may form the foundations for the exploitation of nuclear energy in many countries of the world; others we may some day look back upon as being somewhat curious. It will also be interesting to re-read the discussions in another ten or twenty years' time to refresh our memories on the problems that troubled the nuclear engineer in the early years of atomic energy.

Chemical Processing and Equipment. United States Atomic Energy Commission. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 45s.

THIS book is one of the series of volumes that was sponsored by the United States Atomic Energy Commission as part of the preparations for the Geneva Conference on the Peaceful Uses of Atomic Energy which was held last year. The book, which is excellently produced, falls into two sections: the first, of forty-four pages, deals in some detail with the chemical processing plant at Idaho; while the second, of 258 pages, forms a catalogue of equipment for radioactive laboratories. The Idaho chemical processing plant is designed to recover fissile material from spent reactor fuel elements from various reactors in the United States. In this book the process described is that initially provided for the recovery of uranium from enriched uranium aluminium alloy fuels of the type used in the materials testing reactor. Flow-sheets are given for the process, which consists essentially of a dissolution of the fuel elements in nitric acid followed by continuous liquid—liquid extraction in a number of stages using methyl isobutyl ketone as the solvent. Probably the most interesting part of this section of the book, however, is that concerned with ideas on plant design. It is pointed out that this is the first of the U.S. Atomic Energy Commission's chemical processing facilities that have been designed for direct, instead of remote, maintenance. The authors claim that operating experience at the Idaho chemical plant has definitely proved the feasibility of designing and operating production-scale radiochemical plants using direct maintenance techniques, and that such plants can be built using commercially available equipment, and equipment fabricated according to standard industrial methods. They also state that the choice between design of plant for direct instead of remote maintenance should be made primarily on the basis of plant scale. For large plants, such as those in which plutonium is separated from large quantities of irradiated natural uranium, they believe that provision for remote maintenance or removal of equipment is necessary, because of the difficulty of decontaminating large-scale pieces of plant. For smaller enriched uranium plants, direct maintenance is considered to be desirable because it would be difficult to adapt the many small vessels to the special connectors, required for remote maintenance. There is unfortunately far too little evidence in this book to enable the reader to form any judgment on these claims. No doubt much has been gained on the plant described by making it accessible for maintenance, and it would seem reasonable to suppose that it is simpler than a similar plant would have been if designed for remote maintenance. But the implied division of radioactive chemical plants into remotely or directly maintainable ones seems much too sweeping. The designer of such a plant is first of all concerned, not with such questions as whether he should design for remote or direct maintenance of, say, pumps or valves, but with whether he can in fact design the plant to operate satisfactorily without items which might need maintenance. If a pump is essential, then by careful layout of the plant restricted access to the pump may be obtained without the need to decontaminate much of the plant other than the pump itself. Thus, one would not expect a well-engineered radioactive chemical plant to be designed according to any one maintenance philosophy. Instead, it is surely necessary to strike a proper economic balance between expensive fabrication and inspection techniques (to reduce the risk of active liquor leakage); provision of decontamination facilities and possibly the compartmenting of the plant to allow for direct access; and complication of the plant to allow for remote maintenance.

The second and by far the larger part of the book is a catalogue of equipment for radioactive laboratories. The descriptions of apparatus are of necessity brief. The name of the laboratory in which each piece of equipment is used is, however, quoted, and the number of the reference drawing given. This section of the book would have been of more use if it had been more carefully pruned and fuller descriptions given of the operational problems involved in using some of the more complicated pieces of specialist equipment.

The Theory of Hydrodynamic Stability. By C. C. LIN. Cambridge University Press, Bentley House, 200, Euston Road, London, N.W.1. Price 22s. 6d.

THE outstanding problem of fluid dynamics is the problem of turbulence—the explanation of its generation and the detailed behaviour of turbulent flow. A previous volume by G. K. Batchelor in this series of monographs was concerned with the second part of this problem, the structure of fully developed turbulent flow and its subsequent decay.

This volume by C. C. Lin is closely related to the first part of the problem, the transition from laminar flow to turbulence.

It is necessary to say " closely related " for the following reason. The book investigates the stability of laminar motion of a viscous fluid with respect to infinitesimal disturbances. The method used is to superimpose small sinusoidal disturbances on the linearised flow equations and find under what conditions the disturbances are damped or amplified. This procedure, however, gives little information on the subsequent flow conditions and the instability may not necessarily lead to turbulence but to an intermediate state of flow.

An example of this is the instability of flow between rotating concentric cylinders, Couette flow. Under certain conditions the simple laminar flow breaks down and the flow takes the form of ring-shaped vortices symmetrical about the axis of the cylinders and spaced at regular distances apart. The mathematical solution of the stability of Couette flow by Sir G. I. Taylor in 1923, and its experimental verification, was the first outstanding success of the theory of hydrodynamic stability. The book devotes a chapter to this problem and its solution.

Another problem that has attracted considerable interest and aroused controversy is the stability of plane Poseuille flow, the flow between parallel flat plates. The book deals with this at length and presents C. C. Lin's solution of the problem. The method used is the same as that described previously, where conditions are found for small disturbances to grow exponentially. The solution can be represented by a curve in the disturbance frequency/Reynolds number plane, outside which the flow is stable. This work by Lin and others illustrates the dependence of the critical Reynolds number on the frequency of the disturbance and gives for this type of flow a minimum critical Reynolds number (based on the maximum velocity of the fluid and the half-width of the plates) of about 5300. These results were obtained by lengthy calculations and no general formula was obtained for the critical Reynolds number. As a result nothing can be said with certainty of the flow stability as the Reynolds number becomes very large. It is possible that as the Reynolds number increases to infinity the flow becomes stable for all frequencies, but this problem is not yet solved.

Probably the greatest achievement of hydrodynamic stability theory is Tollmien's analysis of the stability of the boundary layer on a flat plate. It was in 1929 that he predicted boundary layer instabilities, but it was not until nearly fifteen years later that such boundary layer oscillations were observed in a low turbulence wind tunnel by Schubauer and Skramstad. The chapter on boundary layer instability gives an account of Tollmien's work on incompressible flow and later work on compressible flows. The author also discusses the relation between instability and transition to turbulence. For example, in Schubauer and Skramstad's experiments the predicted oscillations were observed at a Reynolds number (based on the distance from the leading edge) of 5×10^4, whereas transition to turbulence was at Reynolds numbers of the order of 10^6. Although the two phenomena are almost certainly related there is still a large gap in our knowledge to be filled between instability and transition. Other sections of the book deal with the entry regions of pipes and channels, the mixing of parallel streams and also various stability problems of astro-and geophysics. The final chapter is a detailed discussion of the mathematical theory and the validity of the methods used.

This book is the first to be devoted solely to the subject of hydrodynamic stability, and the author himself has added much to the knowledge of it. It should be of interest to all engaged in fluid dynamics research and the sections on boundary layer instabilities should be of particular value to aerodynamicists.

Dictionary of the Tool Industry. Vol. I : German-English. Vol. II : English-German. By H. G. FREEMAN. Verlag W. Girardet, Gerswidastrasse 2. Essen. Price DM. 24, each volume.

WITH over 25,000 entries in each volume, the work represents a very extensive collection of technical terms concerned with all kinds of hand tools, industrial tools, measuring equipment, tool materials and production processes. Also dealt with are tools used in fitting, assembly and installation, workshop appliances, jigs and fixtures, and in addition such allied subjects as heat-treatment, surface finishing processes and terms connected with the technology of materials used in the manufacture of tools. The author has indicated those terms which are obsolete or of purely regional significance. In including the corresponding current expressions he has drawn upon the work of national and international standards committees and associations. The dictionary also gives those terms likely to be required by users of catalogues and of publicity material, terms which it is found often differ from those used in the literature. The opening pages contain a large number of useful conversion tables, the most commonly used gauge systems, and alphabetic lists of conversion factors, letter symbols and abbreviations.

Technology of Heat. By H. WRIGHT-BAKER. Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, London, W.1. Price 36s.

THE theory of heat engines is essentially a simple subject, containing only two fundamental principles discovered about a century ago; that there is a constant proportionality between the heat transferred and the work done in a cyclic process ; and that it is impossible for a heat engine to have an efficiency of 100 per cent. Application of these two laws to the experimentally observed properties of working fluids gives the engineer a powerful method of analysing what performance he can expect from his engine and what he must do to improve it. Such application does not require advanced mathematics, compared, for example, with stress analysis ; but it does demand clarity of thought and care in the use of words.

It is regrettable, therefore, to find the subject treated in this book as though it were a mysterious one, and indeed made so for readers by failure to set out the logical structure of the theory or to define the meanings of the key concepts. For example, the term " heat " is used indiscriminately for the interaction between systems which results from their temperature difference, the internal energy of a system, the calorific value of a fuel, and an effect associated with friction ; this prevents the student from understanding the practical implications of the important laws of thermodynamics. Other misconceptions which are propagated are that the steady flow energy equation and Bernoulli's equation have the same content, the latter being restricted to constant temperature flow, and that in general an expanding fluid obeys the equation pv^n=constant. It is true that many other textbooks published in this country have exhibited the same confusion of thought, thus falling far short of the standard set by recent American textbooks, and that nevertheless students have survived to build good engines. But now that novel methods of power production are being developed it is vital that the fundamentals should be understood. What happens when they are not is illustrated by the analysis of the steam injector, on page 205, where the pressure terms have been omitted from equations (3) and (4). Particularly confusing also is the treatment of the effect of friction in steam expansion in a nozzle ; the student is invited (page 233) to believe that some energy " gets lost." The mystery is " explained " by the statement that the " missing quantity has turned into kinetic energy and then into friction reheat which remains in the steam." Since in addition the process is obscured by an attempt to force it into the " pv^n=constant " form, the novice can hardly help wondering whether the first law of thermodynamics does or does not hold for this process. Nevertheless there are some good things in the book, particularly Chapter 11 on heat transfer. The illustrations are good and the printing excellent.

V.D.I.-Berichte, Band 1 " *Technische Formgebung.*" (V.D.I.-Reports, Vol. I : " Industrial Design.") Bielefeld and Berlin, 1954. V.D.I.-Verlag G.m.b.H., Ingenieurhaus, Düsseldorf, German Federal Republic. Price DM. 19·50.

THIS is the first volume of the current series of conference lectures and discussions published by the Verein Deutscher Ingenieure. So far, eight volumes, covering a variety of topics, have been issued, and another nine are in preparation. The present volume is of particular interest as it concerns the general question of the design of industrial forms and is the first German publication on the subject, written by engineers and intended for readers who themselves are technically qualified people. Its purpose is the same as that of the V.D.I.-V.D.M.A. Industrial Design Committee, to promote a greater understanding of beautiful design. The practical importance of good design is nowadays realised by most people. It is not possible at the present time to give exhaustive criteria of what the essentials of good design are. The authors of the various articles here collected endeavour to illuminate the problem from a variety of angles, from the point of view of function and economics of production as well as from the more purely æsthetic aspects. What may perhaps be felt to be the most helpful approach is that of collection and collation of an abundance of illustrated examples, which is the method adopted by most of the contributors to the present volume.

Books Received

Trigonometrical Series. Second edition. By Antoni Zygmund. Chelsea Publishing Company, New York, N.Y. Price 1 dollar 50 cents.

Ship and Boat Builder Annual Review, 1956. John Trundell (Publishers), Ltd., Temple Chambers, Temple Avenue, London, E.C.4. Price 40s.

Engineering Drawing and Geometry. By Randolph P. Hoelscher and Clifford H. Springer. Chapman and Hall, 37, Essex Street, London, W.C.2. Price 64s.

Design of Piping Systems. Second edition. By The M.W. Kellogg Company. Chapman and Hall, 37, Essex Street, London, W.C.2. Price 120s.

Modern Physics : A Textbook for Engineers. By Robert L. Sproull. Chapman and Hall, 37, Essex Street, London, W.C.2. Price 62s.

Rubber in Automobile Engineering. By R. Dean-Averns. The Natural Rubber Development Board, Market Buildings, Mark Lane, London, E.C.3. Price 5s.

The Foreman's Mistake

BY A BARRISTER-AT-LAW

IT is surprising how often it is necessary to look back into the history of a subject, not only to understand its anomalies, but also to be able to apply its principles correctly under modern conditions. A case recently before the courts in which a sheet metal worker sought to recover damages from his employer for the negligence of his foreman illustrates at the same time not only the disappearance of an old distinction which for a long time led to anomalous results in law, but also the emergence of a new principle —the liability of a careless employee to indemnify his employer against the consequences of carelessness.

The workman was not very experienced at his work, having recently transferred from another class of work altogether, and was at the time of the accident under the general supervision of a charge hand. He was engaged, when he injured himself, in replacing the fly-wheel guard over a generator. The guard was of steel plate some $\frac{1}{16}$in thick, and weighed about 28 lb, and the man had some difficulty in replacing it, partly because of its weight, and partly because a copper pipe on the generator was in the way. The copper pipe was secured only by two union nuts, and there would have been no difficulty in the normal way in removing these, but that was the job of a fitter. The sheet metal worker would not touch such a task, and to have the pipe removed would therefore have necessitated calling a fitter. Another difficulty in replacing the guard was that it was slippery with grease : it would have taken some twenty minutes to half an hour to clean off the grease, and the metal worker would not expect to do that job in any case.

The workman therefore endeavoured to replace the cover without tackling the two difficulties first, and was unfortunate enough to cut his thumb very badly on one of the sharp edges of the guard when it slipped from his fingers. As a result he was off work for several months, and suffered a partial loss of movement in this thumb. In an endeavour to recover some compensation for these losses (in addition to his National Health benefits), the workman sued his employers for negligence, alleging, amongst other things, that the system of work was unsafe. He also alleged that the foreman was negligent in supervision.

At the trial, the charge hand accepted full blame for the whole accident in a way which must have been most gratifying to those seeking to make the employer vicariously responsible : " I instructed the workman to perform a dangerous operation," he said ; " the pipe should have been removed first and the cover should have been cleaned." His attitude was, in fact, " it is all my fault." In view of the fact that these admissions were in practice made at the expense of the employer of the two men, the judge was a little loth at first to accept them at face value, but decided that even if the charge hand had done his best to meet the allegations of negligence made against him, there was little that he could have said in his own defence.

The employer, in consequence, was held to be wholly responsible for the man's injury ; the man was at that time working under supervision and it was apparently not suggested in reply to his claim that he bore any of the blame for the accident himself.

For a better appreciation of the reasons underlying the decision against the employer in this case, it is simplest, and quickest in the end, to go back to the first principles of the employer's responsibilities to his men.

The Factories Act lays down certain specific duties which occupiers of factories owe to their employees on the premises ; there are other regulations for special kinds of factories and also for certain other trades and professions : (shopkeepers, for instance, have to comply with other regulations designed for the protection and well-being of their employees and the protection of the public).

In addition to these statutory provisions for particular classes of employees, there are certain basic duties owed by all employers to all their employees, whether they are factory or menial workers, whether they are seventeen years of age or seventy, and whatever the terms of their employment. The duties are basically four : to provide competent staff to work in co-operation with the employee in jobs which necessarily require more than one workman ; to provide adequate materials, by which is meant not an adequate supply of raw materials, but proper equipment, properly maintained ; to provide safe premises, and to provide a safe system of work.

The terminology in which all these duties is expressed is a little outmoded now, for various reasons. The terms are frequently interpreted by the courts and this inevitably extends or restricts the meaning for legal purposes until they are very different from the meanings ordinarily understood. Parliament passes new laws which in part supersede the unwritten doctrines of the common law, or repeals earlier acts of Parliament, and this too has the effect of extending the scope of these doctrines.

The expression " a safe system of work," for instance, has a very different meaning for practical purposes from what it had less than ten years ago, because of the passing of the Law Reform (Personal Injuries) Act of 1948, which abolished the doctrine of common employment. The connection in principle is a little remote, but in practice the two subjects are very closely connected, as the case under discussion shows.

The expression " safe system " used to mean something rather close to what would normally be thought : it was, in fact, the duty of the employer to initiate or devise a safe system by which his employees would be guided in their work. The legal duty of the employer was, in this respect, limited to laying down the general lines for operations of a repetitive or routine nature. He had to lay out a scheme which took into account all the foreseeable risks when the dangers to the workmen involved could be fairly closely calculated.

This duty was in marked contrast with the duty of care on any particular occasion when the employee was engaged on work which was not of a repetitive nature. Where there was no regularity or uniformity in the tasks which the employee had to undertake, there could be no devised system, except, of course, in certain general aspects. Then, if the employee was under the supervision of a charge hand, foreman, or senior employee in the particular job on which he was working, any dangerous course of action on the job in hand would tend to be the immediate responsibility of that senior employee. In that event the employer was, up till 1948, not liable for injuries resulting from an accident because of the doctrine of common employment.

In the case of injury of a workman not on a routine job, therefore, who sustained an injury, the employer was formerly liable for the damage if it could be shown that there was some omission to take care which was part of a general system, or happened as a general rule, but the employee failed in any claim against the employer if the act of omission could more properly be ascribed to an isolated act of carelessness on the part of a fellow employee.

Now that the doctrine of common employment has been abolished, and the employer is responsible in any case for the negligence of all his employees which causes injury to fellow employees (as well as to outside parties), the distinction between the particular and the general, between the fault in the system of work, that is, and the isolated act of carelessness on the part of the supervisor or fellow workman, has for practical purposes disappeared.

Nevertheless, the duty on the employer to provide a safe system of work remains. Though he cannot avoid liability for isolated acts of his employees which cause injury to others besides themselves, he can still prescribe rules for the safety of all the operations which are carried on in pursuance of his instructions or for his profit, and it remains in law his duty to do so.

There is another consideration, too : if a man is injured substantially through his own carelessness, the distinction between a system and an isolated act becomes once again of importance. If the man has been engaged upon an operation which it is in the normal course of his work to do, and it can in the general sense of the words be said that he is working to a system of work, the employer will certainly be held responsible if it is found that the man was undertaking his task in a dangerous way which was either prescribed by the employer, or even only within his knowledge. In this connection his knowledge includes the knowledge of his foreman or other supervising or instructing staff. If, on the other hand, the occasion on which the accident occurred was an isolated one, the responsibility for the risk taken will almost certainly be that of the employee alone. In this event, his claim for compensation will fail entirely.

If the responsibility is shared, both the employer and the injured man will share the loss ; this means that the damages will be assessed and divided in proportion to the blame of each, so that the sum recovered by the employee will be reduced in proportion to the amount of his own blame for the accident.

This lawsuit also illustrates another principle of law, the " new principle " mentioned in the opening paragraph : it is actually of very long standing, but has seldom been invoked in the past. It may, though, become of increasing importance in the future. The employer in this case was liable to the workman injured because of the carelessness of the foreman ; the foreman was not sued directly by the injured man, but there is no reason why he should not have been, except the practical reason that the employer usually has more money to pay compensation. The employer still has the right to recover what he pays out, though, by claiming a reimbursement in turn from the foreman who was really at fault in the whole affair. This principle has just been affirmed in the Court of Appeal in another case, and may become of increasing import-

ance in the future. The financial gap between employers and employees is becoming much more narrow, particularly in smaller businesses in some trades, than it used to be, and there may well come a time when an employer of one or two men may genuinely need to recover from a careless workman at least part of the cost incurred by a careless act towards an outside party or a fellow employee.

Electric Glass Melting Furnace

By A. GELL*

On May 30th, the Society of Glass Technology heard some observations on the design and operation of an all-electric glass melting furnace. We reproduce a condensed version of the address.

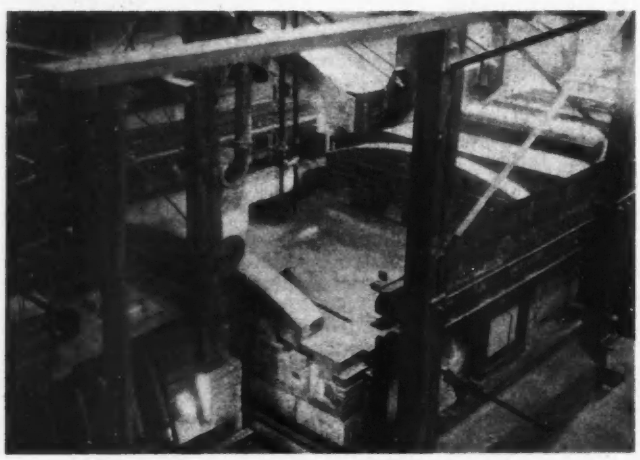
THE object of this paper is to consider some of the main factors affecting the electric melting of glass and from these to trace the development of an all-electric furnace.

Others, including Dr. Ivan Peyches, the director of research of the Cie. St. Gobain, have already investigated and lectured on the properties and electrical characteristics of glass. However, in an electric glass melting furnace of the resistance type, variations in the composition of the glass may widely affect its electrical characteristic at molten temperature. To appreciate exactly what takes place when glass is subjected to an electric current it is necessary briefly to summarise its physical structure as at present understood.

A glass comprises a network of structure building units held together at their corners, consisting of nuclei of atoms such as silicon or boron, surrounded by links of anions such as oxygen ; " modifying " cations such as sodium and calcium are enclosed in the " holes " in this network. At high temperatures the alkali metal ions are substantially free and they will travel through the network towards the cathode if a potential difference is applied to electrodes in contact with, or immersed in, the glass. In all glasses which contain alkali it is the univalent alkali metal ions which largely carry the current. The lower the atomic weight of the ion, the higher is its mobility ; consequently, lithium gives a higher conductivity than sodium when equal numbers of the two ions are present in similar glasses under similar temperature conditions. Correspondingly, sodium gives a higher conductivity than potassium. The negatively charged anions are, on the other hand, believed to be related primarily to viscosity and play little part in carrying current.

In the soda-lime bottle glass exothermic heat seems to account for an actual reduction in the calculated power required for melting 100 lb of glass per hour of up to as much as 8·5kW. Similarly, in a borosilicate glass, where there is a lesser reaction between the nitrate of soda and the silica, a saving of only 2·5kW per 100 lb of glass melted per hour seems to be accounted for in this way. When glass is melted electrically conditions can be arranged so that considerable local turbulence takes place in the glass. In order to ensure good mixing it is not therefore necessary to introduce batch materials which give off large amounts of gas as they decompose. The volatilisation of the gases requires unnecessary use of electric energy and it is advantageous to have as little gas evolved as possible. In practice it is, of course, necessary to use certain batch materials which give off gases, but by suitable choice of materials the amount of gas to be dealt with can be kept low and can be driven off at a fairly early stage during the melting process.

The adjustments which have to be made to fuel-fired batches to compensate for refractory erosion can, in electric melting, largely be ignored, for the rate of melting is considerably higher in relation to the surface area of the refractory in contact with the melting glass. Thus, the glass composition will correspond very closely with the composition calculated from the batch.



The furnace crown is here seen raised

The thermal efficiency of a fuel-fired glass melting furnace is normally not greater than 5 to 15 per cent. Where, however, electricity can be converted into heat within the body of the glass, a saving in heat loss results and all electric furnaces so far designed and operated have demonstrated this fact. However, the majority of those in commercial use still comply with the fuel-fired furnace conception of melting and refining ; that is to say, the raw material is introduced at one end of the furnace, and passes horizontally and successively through a melting zone, a refining zone or zone of maximum temperature corresponding to the spring of the fuel-fired furnace, and a throat to a working chamber. Within these furnaces the glass will vary in temperature according to the zone through which it is passing. Such electric furnaces can be said to fall into two groups—first, those in which the intensity of the current, and therefore the heat, is achieved by a restriction in the dimension of the furnace at the fining zone—for example, furnaces designed by Sauvageon, Raeder, Hitner, and some Russians, e.g. Grebertchnikof. The second group of furnaces consists of those with concentrating electrodes ; in these furnaces the glass receives its maximum temperature boost within the near vicinity of the electrodes and thus is subjected to intense convection currents within the area adjacent to the " fining " electrodes. The remaining glass within the melting chamber attains a proportion of the total heat introduced from the energised glass by the absorption of calorific radiation. The melting and " fining " of the glass may take place either in the same chamber or in different chambers under the system known as deferred melting. The well-known furnaces developed by Borel in Switzerland and Dr. Peyches in France are the principal examples of this second group.

However, it must be admitted that molten glass has a relatively high viscosity, poor thermal conductivity and a poor transmission of calorific radiation. In both these main groups of electric furnaces the melting and refining chambers can be considered as partially ineffective, as the glass within is not subjected throughout to a high current density. It is also fair to comment that a proportion of the heat developed is dissipated by radiation from the glass surface. It is, however, probable that the design of both groups of furnaces has to some extent been influenced by the phenomenon of electrolytic gassing. Were the molten glass subjected to a direct current, electrolysis would occur : even with alternating current of 50 c/s electrolytic gassing can take place on the electrodes when the current density per unit of the electrode face exceeds a certain value. One satisfactory solution has been to increase the frequency, but this is not normally commercially acceptable.

An improved performance from electric melting can be expected and heat losses further reduced if a solution to two problems can be achieved. These are :

In order to attain the most effective power input from alternating current at mains frequency and without danger of electrolytic gassing, can the area of the opposing electrodes be increased?

As the heat is developed within the body of the glass, can the glass surface of the melting chamber be insulated in the same way as the other sides ?

In addition, can the volume of glass in the melting and refining chamber be increased in relation to the surface areas of the insulating surfaces ?

The Furnace Design

To reduce heat losses to a minimum the melting chamber should ideally form a cube. It consists, in fact, of a rectangular prism with electrode barriers covering two opposite sides. In order that the top surface may be wholly insulated the batch is fed on as a floating carpet which covers the entire surface and forms a batch crust of unmelted frit ; a crust can be formed which has very nearly the same insulating properties as a refractory lining. The melting chamber is so designed that at its highest melting rate the electrode barriers are subjected to nearly the maximum permissible current density. The glass when refined is withdrawn from the bottom of the chamber ; since the melting batch offers a greater resistance to the passage of an electric current than refined glass, the current density across the furnace will tend to rise towards the bottom of the melting chamber and provide a greater temperature where it is desired for the final refining of the glass.

Within the melting chamber convection currents do not take place. Instead, considerable local turbulence occurs between the electrode barriers in both the melting and refining zones. The heat rising from these zones is sufficient to melt off the underside of the batch crust. Thus, as the glass is withdrawn from the base of the melting chamber so is melting glass liquified from the underside of the batch crust, which is maintained by further charges.

The dimensions of the chamber depend on certain critical factors which have to be calculated for each individual furnace. The distance between the electrodes, i.e. the electrical length of the chamber, will determine the voltage characteristic, which is also dependent on the composition of the glass to be melted. In commercial furnaces the voltage cannot exceed 600 without creating complications in the design of the electrical equipment.

The limitations imposed on the depth depend on the depth of the electrode lining of the two opposite sides. These linings may be formed of molybdenum strips, to which the current is transmitted by cooled feeders passing through the refractory insulation, and at present they cannot be manufactured above a certain length. Moreover, above the electrodes there is a critical depth, which varies for each type of glass melted.

With commercial grade refractories it is possible to operate the furnace at temperatures of up to 1640 deg. Cent. While at present the temperature limitations imposed by available

* British Heat Resisting Glass Company, Ltd.

refractory materials alone restrict the temperature at which the furnace can operate, this can to some extent be overcome by the careful application of external cooling.

The glass withdrawn from the base of the melting chamber while wholly refined is too hot to be worked ; it is, therefore let through a submerged channel to a small operating forehearth or feeder extension. Within this channel the glass cools evenly back to working temperature.

While each electric furnace is designed for a specified optimum melting rate, it must be flexible in use. With a soda-lime glass a rise of 50 deg. Cent. in the melting temperature will roughly double the rate of melting. Thus, there will be variations in the temperature at the base of the melting chamber should the furnace be required to work at anything less than its optimum rate. The glass in the feeder extension, however, will be required for working at a constant temperature regardless of variations in the temperature within the melting chamber. The forehearth or feeder extension consists merely of the small chamber in which approximately two hour's supply of glass at working temperature is at all times available for the feeder. While the furnace is all-electric, within the forehearth it is necessary to heat the crown to the same temperature as the glass beneath it to maintain uniform temperature throughout the glass. This can be done by electric resistance heating bars, but at present it has been found to be more economical to use gas and air burners for this purpose.

The regulation of the furnace is critical and could be attained either by the use of stepless voltage regulators or saturable reactors ; the former are preferred as providing a less peaky wave form to the current cycle passing through the glass.

It is more than likely that electrolytic gassing is related to the peak rather than to the mean current density. For this reason it is important that the wave form of the cycle of the melting current should approach as nearly to that of a sine wave as possible. As melting takes place vertically downwards, it is desirable to avoid variations in current density through any horizontal cross-section of the melting chamber.

The settings of the electrical equipment for each furnace have to be adjusted to suit the type of glass melted and the load to be taken from the furnace, for the power required for a given rate of melting for a specific glass is critical ; an error in the settings will provide conditions under which the furnace will become unstable, that is to say, if the power introduced is too great for any actual rate of throughput the resistance will fall, the temperature will rise, the current will increase, and so on. The effect is cumulative and the furnace will grow hotter and hotter until some part fails. Conversely, if the power is insufficient, the opposite effect will take place and the furnace will slowly cool down.

However, once the furnace has been set correctly, it becomes stable within limits of up to 5 per cent on either side of the conditions set for any rate of throughput, tending to hunt towards the appropriate conditions rather than away from them.

It is possible for the regulation of the furnace to be effected by automatic control. The regulation of the currents and of the timing of the batch charger has been achieved by an electronic computer, which was controlled from a forehearth level control consisting of a particle of radioactive strontium and a sensitised counter.

The starting up of electric furnaces of this type is in principle no different from that of others. The available voltage will not be sufficient to cause the current to pass until the glass has reached a certain temperature : the initiation of the current across the glass can be achieved in several ways. While a trail of a conducting substance between the electrode barriers or the introduction into the bath of arcing electrodes can be effective, the method which is normally preferred is to fit a small temporary crown over the surface of the melting chamber and to heat the surface of the cullet within the melting chamber by gas until the resistance of the glass is sufficiently reduced. This electric furnace can be ready for working in a comparatively short time after starting up : with a high silica glass the furnace is normally in full production within six days of first lighting the gas.

Its putting out is equally simple. In putting the furnace out subsidiary electrodes are connected to a suitable power supply and the glass is run off into a pit beneath the furnace. In order to prevent the molybdenum electrode faces from oxidising the small temporary crown is again placed over the melting chamber and unburnt gas introduced until the molybdenum electrode faces have cooled to a sufficiently low temperature for no oxidisation to take place.

One of the main objectives in the design of this furnace was the reduction of unnecessary heat losses. With the furnaces now in operation the heat losses in the melting chamber have been reduced so that a thermal efficiency of some 50 to 60 per cent is obtained. Ordinary soda-lime bottle glasses have already been successfully melted at rates in excess of 1 ton per 2 square feet of surface area per day, or, as the glass is really melting and refining vertically, in excess of 1 ton per 3 cubic feet per day. The electric furnace installation occupies considerably less space in all three dimensions and requires no special building to house it. By comparison with a similar fuel-fired furnace the refractory materials required are in the proportion of1 to 4 by weight, and the campaign life is normally in excess of one year. On account of the few refractory blocks which require to be replaced at the periodic rebuild, this can be quickly effected with an equivalent saving in maintenance and repair cost and in idle time.

With a soda-lime glass of this type the glass remains in the melting chamber for not more than eight hours and is passed through the channel and the forehearth in no more than a further five hours. For a borosilicate glass the rate of throughput is not quite so rapid. Moreover, if impurities are by mischance introduced into the raw batch materials the fact can quickly be noticed and the matter put right with the minimum loss of production time.

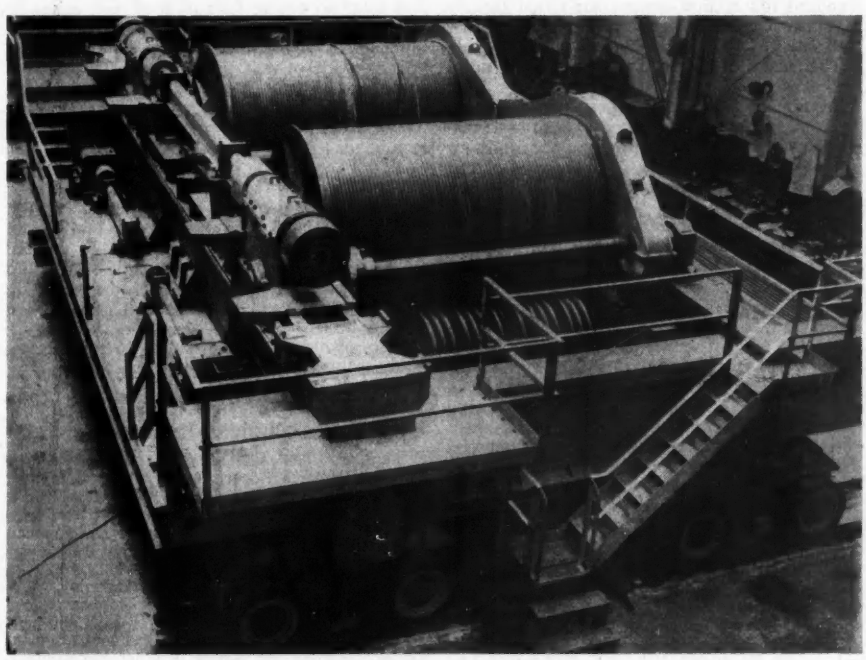
With electric melting there is no leaching out of batch constituents or introduction of impurities from flame combustion. All the glass receives substantially identical treatment in the melting and refining zones and a more homogeneous glass results, largely due to the turbulence throughout the melting chamber. It has been found that the quality of glass can be maintained with a marked reduction in the amount of the decolouriser normally required. For instance, in a soda-lime bottle glass, for fuel-fired melting purposes, approximately $\frac{1}{2}$ oz of selenium is required for every 1000 lb of sand in the batch mix. When this mixture is introduced to an all-electric furnace the resultant glass becomes pink, and the selenium content can be reduced to $\frac{1}{16}$ oz or less to provide the white glass required.

410-Ton Ladle Crane

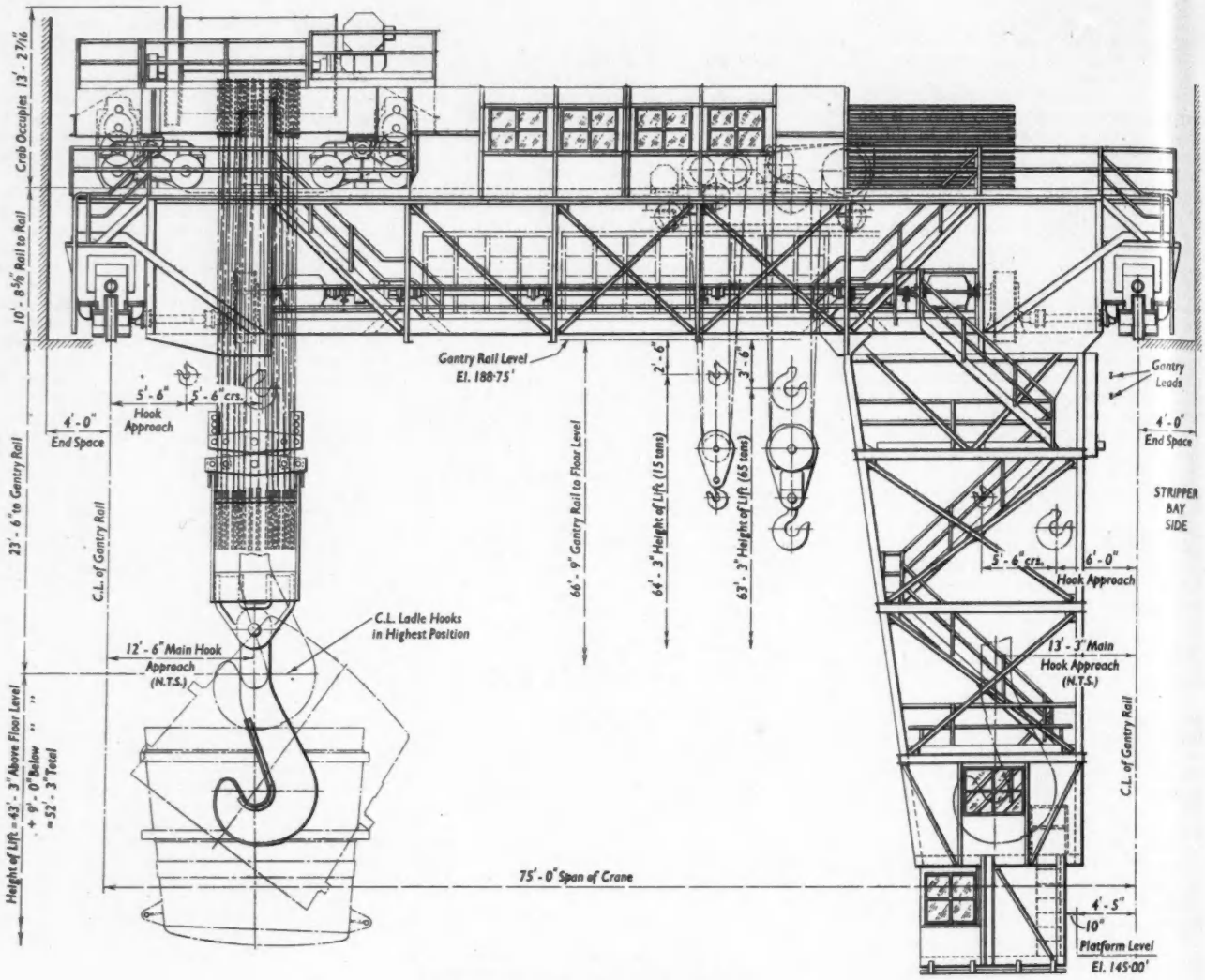
PARTICULARS have been received from Joseph Adamson and Co., Ltd., Hyde, Cheshire, of a 410-ton ladle crane which has been supplied to the Australian Iron and Steel Company. This four-girder crane has a span of 75ft and the width over its buffers is about 69ft 6in. The main load is carried on sixty falls of rope reeved on two 7ft diameter barrels. An auxiliary trolley has two hoists of 65 and 15 tons capacity respectively.

The general arrangement of the crane can be seen in the drawing we reproduce on page 644, and the main trolley assembled at the maker's works is shown in the accompanying photograph. The box section girders for both the main and the auxiliary trolley have end tie bracings on which the auxiliary girders are carried. Saddle brackets at the ends of the bridge carry fabricated yokes to which there are fitted at each end three wheeled bogies having a double compensating device. With this arrangement the bridge is carried on twenty-four runners on the gantry rails, and eight of these wheels are driven. Four bridge motors of 75 h.p. each are fitted. Two motors for this drive are situated one at each end of the bridge on each side, and they are connected through gearing, a cross shaft, cardan shafts and half-geared flexible couplings to two extended runner axles in each bogie. The drive is designed to ensure efficient transmission whilst permitting the bogies to oscillate due to any irregularities of the gantry. The bridge runners are carried on large axles through oil-box-mounted bearings with pad lubrication.

The contactor gear and resistances are built into separate enclosed compartments carried on the platform between the main and lattice outrigger girders. The operator's cabin, situated some 43ft below the gantry rail, is a completely enclosed and insulated structure fitted with



Main trolley of 410-ton ladle crane, fitted with two 200 h.p. motors and raising the load through sixty falls of rope



General arrangement of 410-ton ladle crane

double armour plate glass windows, lined with fibre wool between the inside and outside walls, and air conditioned.

The conductors on the bridge are of the standard rail section design, supported from a platform which is screened from the girder walkway.

The frames of the main trolley are built up of heavy welded structural steel sections with welded main beams. The design is such that all primary stresses are carried back to two main beams, which are supported at the ends by saddle brackets carried on the pivot pins of four four-wheel compensating bogies, as can be seen in the illustration.

The hoist on the main trolley is of two-motor, double-gear, interlocked drum design, each of the interlocked drums mating with pinions carried on shafts with a worm gear at one end. One of these worm gears is cut right hand and the other left hand; they are placed in line with each other and at right angles to the hoisting drums. Each worm is connected to a 200 h.p. motor through a flexible coupling, the two worms being connected to each other by a line shaft and geared flexible coupling. This arrangement permits simple and accurate adjustment between the two lines of gearing, so that although the drum gears are intermeshing there is no actual contact between the teeth of the idler pinions in the normal operation of the crane. This is a safety measure which would come into operation in the case of mechanical trouble or could be used as an emergency measure in the case of motor failure. This main hoist has a hoisting speed of 8·8ft per minute with a load of 410 tons and its cross traverse rate is 65ft per minute. The two main hoist motors are synchronised to share inequalities of load in case of poor brake adjustment, and a rope safety arrangement on the hoist allows one rope or two diagonally opposite ropes to brake without altering the position of the ladle beam.

The 65-ton hoist of the auxiliary trolley carries the load on twelve falls of rope and raises its maximum load at 26ft per minute. The 15-ton auxiliary hoist has eight falls of rope and has a lifting speed of 40ft per minute. This smaller capacity hoist is fitted with a magnetic cable drum. The auxiliary trolley is carried on four runners on the crane bridge along which it can be moved at a speed of 150ft per minute.

All of the gearing on the crane is enclosed in dustproof, oiltight gearboxes, and the bearings, with the exception of single pedestal bearings, are all arranged for effective oil lubrication. In most cases the gears are carried on parallel roller bearings on one side of a stub shaft, and on spherical roller bearings on the other side.

We are informed by the makers that in addition to this crane there are also being supplied a 170-ton ladle crane, a 200-ton stripper crane, and thirty-two soaking pit chargers.

Technical Reports

Researches into the Welding of Aluminium and its Alloys. Research Report No. 27. The Aluminium Development Association, 33, Grosvenor Street, London, W.1. Price 7s. 6d.—This report is a summary of the work of the Aluminium Development Association's Welding Research Team at the University of Birmingham, 1944 to 1950, and has been prepared by Dr. W. I. Pumphrey. It includes individual investigations which have been presented to the learned societies or have appeared as articles in the technical press and presents them in this form for the benefit of other investigators. An appreciation of the work is given by Professor A. J. Murphy, M.Sc., and this is followed by an analysis of the various researches presented in the form of a family tree. The main sections of the report are concerned with cracking at temperatures above and below the solidus; factors affecting weldability; temperature distribution during the welding of aluminium alloys; the development of alloys having good welding and mechanical properties; cracking diagrams for aluminium alloys. There are two appendices; Appendix I describes the cracking tests used, such as the ring casting test and the restrained-weld test, and Appendix II lists the papers published by the welding research team.

The Thermal Insulation of Buildings. H.M. Stationery Office, for Department of Scientific and Industrial Research, London. Price 12s. 6d.—*The Thermal Insulation of Buildings* is intended as a manual for the use of building designers. Its contents have been compiled by the Building Research Station to provide a guide to the use of heat-insulating materials, their performance and their cost. It opens with an outline of the principles of thermal insulation which, while it does not attempt to deal comprehensively with the theory of the subject, is intended to provide sufficient background information to enable the reader to make the best use of the data sheets and tables that follow. The data sheets deal with the properties of the various heat insulating materials available to the designer, and the tables give the thermal transmittance values and costs of wall and floor constructions with satisfactory insulating properties.

Full-Scale Investigation into the Hydrodynamic Behaviour of a Highly Faired Flying-Boat Hull. By J. A. Hamilton. R. and M. 2899. H.M. Stationery Office. Price 10s.—The hull of a 50,000 lb "Sunderland" flying-boat was fitted with a fairing behind the main step, ducts being provided to pass air from ports on the hull side to exit vents on the planing bottom. A ventilating area of 0·042 (beam)^2 immediately behind the main step was found to confer satisfactory hydrodynamic qualities. Only an angular discontinuity in the vertical plane, as distinct from a step between forebody and afterbody, was found to be necessary.

Australian Steel-Using Industries

THE completion of the continuous hot strip mill at Port Kembla, N.S.W., which the Commonwealth Prime Minister opened last August, marked the halfway stage in the great post-war expansion programme of the Australian iron and steel industry. Since 1945 the Broken Hill Proprietary Group has already spent over £60,000,000 on the programme, details of which have from time to time formed the subject of articles in this journal. The activities of the Group and its subsidiaries have spread in many directions, notably in large extensions of plant at Port Kembla, the modernisation of plant at Newcastle and of the collieries in New South Wales, the opening of new sources of iron ore and in various developments in South and Western Australia. When the Newcastle works were opened forty-one years ago, Australian output of steel was only 200,000 tons from the Lithgow works of G. and S. Hoskins, Ltd.—now Australian Iron and Steel, Ltd., one of the B.H.P. Group. Production capacity is now 2,300,000 steel ingot tons and this will be increased to 2,650,000 by the end of this year, when the first two furnaces of a new open-hearth shop at Port Kembla are completed. The second half of the programme is to cost a further £60,000,000 in the next five years and will include the construction of a continuous cold strip mill and tin-plate plant at Port Kembla and new rolling mills both at Newcastle and Port Kembla.

Among the more important steel-using and finishing firms to benefit from this expansion of the steel industry are those which cater for the rural industries. The highly prosperous condition of Australian farming during the past ten years has had a marked effect on the demand for certain kinds of steel products, including fencing wire—barbed and plain—wire netting, fencing posts, pipes and galvanised iron. Subdivision of holdings has meant many more miles of fencing and fencing, moreover, of a higher standard than previously. Almost since they came into popular use seventy or eighty years ago steel fencing wire, wire netting and steel sheet have been in great demand by the farmers of Australia, and some of the earliest manufacturing works in Melbourne, Sydney and the larger country towns were set up to cater for that demand. Wire and wire netting works, using imported rod, came into existence both in Sydney and Melbourne in the 1880s and an attempt to roll galvanised iron sheets was made at Lithgow as early as the late 1870s. Australia's imports of wire and wire products rapidly mounted until the intervention of World War I. Serious shortages then occurred—British, Continental and American wire being difficult or impossible to procure—and there at once arose an incentive to expand its manufacture in Australia. During that war the position was transformed by the setting up by B.H.P. of a modern steel works at Newcastle, to which was added in 1918 a Morgan rod mill. For the first time Australia's wire manufacturers could look to local sources to supply their raw materials and they at once set out to take advantage of the development. A beginning was made in 1918 with the erection of a new wire mill alongside the B.H.P.'s works at Newcastle by the Austral Nail Company. This company was absorbed in 1921 by a British firm to become Rylands Bros. (Aust.) Proprietary, Ltd. Several large steel-using firms soon afterwards established themselves in the district as neighbours and customers of B.H.P.'s recently established steel works. They included the steel sheet and wire rope-making industries, as well as Rylands. In all of these British capital played a predominant part in the early stages. Together, these industries represented a very considerable addition to Australia's industrial potential, but they were by no means able to meet the whole of the Australian demand for steel in the 1920s. Steel usage rose to new levels during that decade, as a result of vigorous public works programmes and agricultural expansion, and imports of steel remained high. In spite of some protection afforded by the tariff, locally-made steel and the products derived therefrom had difficulty in competing with imports, and it was not until 1934 that B.H.P. steel could readily undersell duty-free imports. In the meantime several of the steel-using industries which started life with such high hopes after the war had come up against serious economic difficulty. To preserve them as users of its semi-finished rolled steel products, although itself hard pressed, B.H.P. interested itself in a number of them, including Rylands Bros. (Aust.) Pty., Ltd., and Lysaght Bros. and Co. Pty., Ltd., now members of the B.H.P. Group. In helping to finance these companies and in becoming subsequently the majority shareholder, B.H.P. succeeded not only in preserving, but later in enlarging, the local market for Australian-made steel. In the 1930s the local position was further strengthened and expansion accelerated. A third wire manufacturing firm, Titan Nail and Wire Pty., Ltd., in which B.H.P. for some time had had a financial interest and which had been accustomed to draw on the steel works for its raw material, joined the group in 1933. Soon the three wire products subsidiary companies were meeting almost all of Australia's pre-1939 needs. The emergence of the B.H.P. Group of steel-using companies was thus the outcome of the unfavourable economic conditions manufacturing industry in Australia ran into after World War I. By forming a group with itself at the centre, B.H.P. was better able to weather the uncertainties of those early years. In so doing it was following a well-established tendency in all the main iron and steel-producing countries. The revival in the demand for these products was one of the first signs of returning confidence after 1933. During the past twenty years the three companies have remained the most important suppliers of these commodities, and since their price has remained more favourable than that of imports considerable numbers of farmers and others have benefited accordingly. Productive capacity has been added to considerably since 1935, although in recent years the tremendous rise in demand has exceeded the capacity of the three firms to supply. For some years after 1934, Australia was practically self-sufficient and imports of wire and wire products which had been consistently high until 1929, fell to a low figure. Since the last war, however, prosperous conditions on Australia's farms have created an unprecedented demand and imports have again become necessary. Some little time may have to elapse before Australia's own wire mills will be in a position to cope with the new demand.

Other important firms manufacturing specialised steel products at Newcastle since the 'twenties are the Australian Wire Rope Works Proprietary, Ltd., and the Commonwealth Steel Company, Ltd. Both became members of the B.H.P. Group in 1935 and have been considerably expanded and modernised, particularly since the war. The Rope Works Company draws its raw material in the form of wire from Rylands Bros. (Aust.) Pty., Ltd., nearby and converts it into wire ropes for a wide range of uses, for transmission lines, colliery haulage, earth-moving equipment, open-cut mining and ropes for general engineering purposes. The ropery's annual capacity is of the order of 10,000 tons of product. At the present time the Australian demand is somewhat in excess of the plant's output, which is limited mainly by the quantity of wire Rylands Bros. is able to supply to it. Plans now in hand, however, will increase output. Although one of the smallest of the group's wire-making and processing firms, it is probably the most highly mechanised. Much of its post-war development has been concerned with plant improvement. Additions to capacity have included radial and bench drilling machines, a six bobbins by 17in tube stranding machine, a twenty-four bobbins by 17in tube stranding machine, and a 2-ton high-speed tube closing machine. The Commonwealth Steel Company was equipped initially to manufacture forgings and castings from B.H.P. steel and was then mainly engaged in catering for the needs of the Government railways and tramways, which are large users of forged and cast steel for wheels, wheel tyres and axles. Later the company set itself out to produce special steels, and one of the first items of plant to be installed was an electric arc Heroult furnace. Commonwealth Steel has pride of place in being Australia's first manufacturer of electric steel. The special steels side of the business grew in importance and a second Heroult arc furnace was added in 1934. In 1939 a major expansion of activities was initiated, which continued during the early years of the war. The new installations included plant for making a complete range of constructional, alloy, tool and stainless steels. They included an acid open-hearth furnace, a third electric arc furnace, two high-frequency furnaces, a tool steel forge plant and rolling mills for the manufacture of special merchant bar and stainless steel sheet. Rolling equipment included a 30in bloom mill, two sheet rolling mills and a 12in merchant mill, together with heat-treatment and finishing equipment. The expansion of Commonwealth Steel Company, Ltd.'s range of activities was timely, to say the least, since it made available a supply of special steels at a time when the very existence of the nation depended upon it. No Australian industrial plant played a more vital role in defence and Commonwealth Steel Company, Ltd., emerged from the war as the nation's most important and in some cases only producer of alloy steels, including stainless steel sheet and tool steels. The very considerable developments of the war-time years have been steadily built on since 1945. The smelting and rolling of alloy steels call for much technical skill and Commonwealth Steel Company, Ltd., has given attention to improving techniques and qualities, and to developing new kinds of alloy steels. The manufacture of these products on a large scale is comparatively new to Australia, and it is generally regarded as a more difficult and costly process than the production of the normal range of carbon steels. Additions to plant at the Newcastle works since 1945 have been many and varied. They range from an extension of the stainless steel sheet mill and additions to equipment for heat-treatment, to the erection and housing of a 5100-ton capacity Schloemann forging press. The latter has been a substantial undertaking, but its installation is now completed. Commonwealth Steel Company, Ltd., has co-operated with the Federal authorities in this project, since the forge press was acquired from Germany as portion of the reparations for the recent war. The Schloemann press is possibly the largest unit of its kind in the Southern Hemisphere, and equips Australia to handle ingots up to 150 tons in weight, three times more massive than have been possible in the past. While remaining the property of the Federal Government, the press will be leased to Commonwealth Steel Company, Ltd., and used, as required, for commercial purposes. In a plant as large and as varied as that operated by Commonwealth Steel Company, Ltd., improvements and additions are part of the normal course of events. Much money has been spent in the post-war years in raising both the efficiency and capacity of the many departments. On the steel-making side existing capacity is approximately 65,000 tons of liquid steel a year (open-hearth, electric arc and high-frequency). Installed capacity to manufacture forgings and castings is of the order of 30,000 tons a year. Output of rolled special steel products, including stainless steel sheet, has averaged approximately 18,000 tons during the past three years.

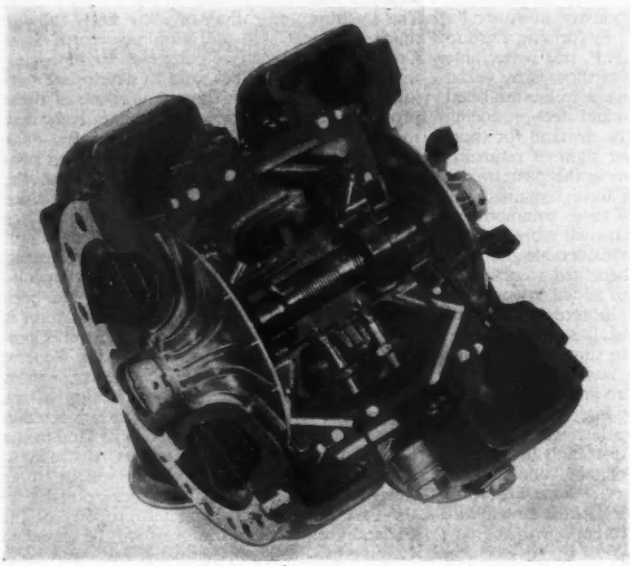
THIXOTROPIC PAINT.—A new thixotropic decorative paint developed by Allweather Paints, Ltd., 36, Great Queen Street, London, W.C.2, resembles ordinary jelly in consistency, and it remains in the same condition from the time it is made. It is ready for use immediately the lid is removed, no stirring being necessary, and there is no colour variation during use. Being thixotropic, a substantial quantity of paint is picked up by the brush when painting and a large area is covered each time. The action of brushing causes the paint to flow, and it spreads smoothly and evenly without leaving brush marks. Stirring or undue agitation in the tins turns thixotropic paint to liquid, but it reverts to its semi-solid state on standing. The makers point out that during normal use the paint will not spill if the tin is knocked over, nor will it drip off the brush. This paint is available in sixteen colours, in addition to black and white, and can be supplied in gloss or flat finish.

Air Cycle Refrigeration

A FAVOURED method of cooling the air used for cabin atmosphere conditioning in aircraft is expansion through an air turbine. The heat abstracted can be dissipated in a brake, typically an idle air compressor, or a fan inducing cooling air through a heat exchanger, which cools the air input to the turbine. The greatest temperature difference results in the heat exchanger when the load on the turbine is a compressor heating the working fluid and passing it into the heat exchanger before expansion in the turbine : all the heat abstracted by the turbine has previously been added to the air by the compressor, but the dissipation from the heat exchanger is greatly increased.

Such a turbo-compressor cold air unit has now been applied by the makers, Sir George Godfrey and Partners, Ltd., to air cycle refrigeration. This is the reverse of its normal application, since the mode of working is to heat the working fluid from a low temperature source. Thus, the air enters, not through the compressor, but through the turbine. It is then heated in the cold chamber and, in order to put the maximum load on the turbine, further heated by heat exchangers in the supply to the turbine. The air then enters the compressor.

A cold air unit running in this manner can readily achieve temperatures around −120 deg. Cent. The working fluid must, therefore, be dried. The cooler is coupled to a dehumidifier including two silica-gel adsorbers. While one of the adsorbers is in action, the other is being reactivated by passing through it the compressor discharge air, further heated by electricity. Water cooled coils dissipate the heat evolved during the air drying process. A low temperature unit for research purposes, able to handle a load of 2 h.p. per hour at −90 deg. Cent., and reach that temperature within one hour, runs at 20 lb per minute (roughly 250 cubic feet per minute free air) of air at 80 lb per square inch pressure and temperature not exceeding 25 deg. Cent. Each adsorber will hold the dew point below −30 deg. Cent. for two hours before reactivation. Reactivation takes one and a half hours, the heater then being turned off and the silica gel allowed to cool before further use. The air in the cold chamber is circulated through a heat exchanger by an electric fan : another electric fan can supply air to the heater for reactivating the silica gel when the cooler is shut down.

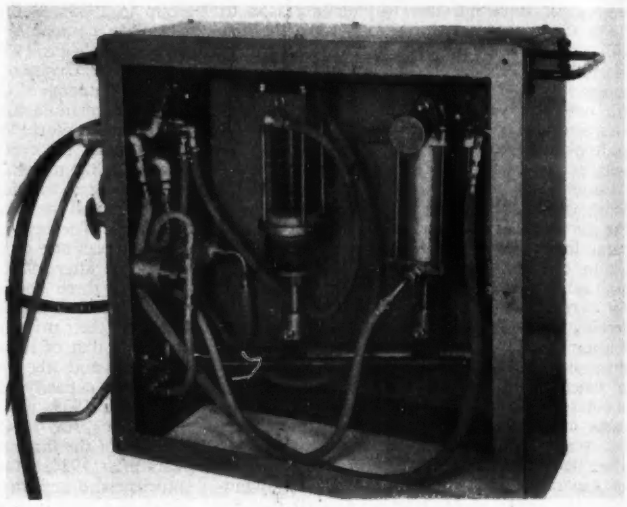


Turbo-compressor of a cold air unit

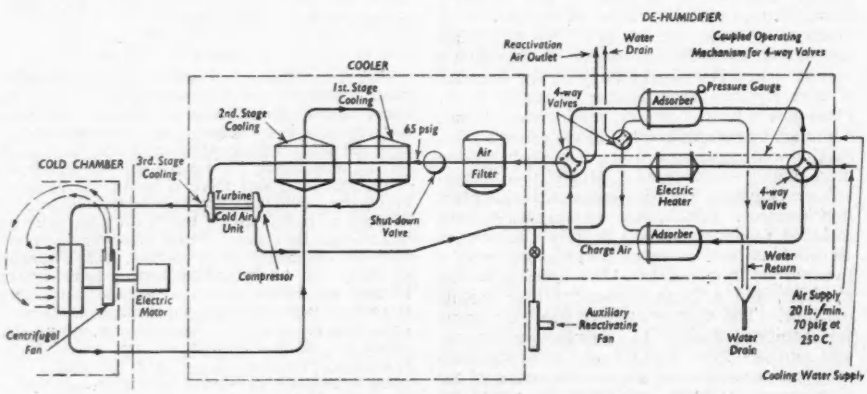
Liquid Additive Metering

ON a recent visit to the Wembley works of Atlas Copco (Great Britain), Ltd., we were able to study the equipment the firm has evolved to dispense liquids requiring the addition of catalysts. Finishes of the urea-formaldehyde, polyester and epikote classes dry catalytically, and apart from painting, fibre glass laminates are bound together with catalysed resins. In all cases the solidification begins as soon as the catalyst is added, so that if the liquids are mixed before use only small quantities can be prepared. If the mixture is to be applied by such a device as a spray gun, premixing introduces the disadvantage that the mixture must be cleared completely from the apparatus before it can solidify. The dispenser we were shown meters and delivers the resin and the catalyst separately, and only after leaving the plant do they mix. In this instance a spray gun, a modified version of an "Ecco" pressure feed spray gun fitted with a hollow needle, delivered the mixture. The resin passes through the nozzle in the normal way, while the catalyst is fed through the needle, becoming the core of the liquid stream. When compressed air is used to atomise the liquid, it is claimed that the two liquids become thoroughly mixed and are homogeneously distributed through the spray.

The resin or lacquer is stored in a pressure container, the catalyst in a polythene bucket, feeding by gravity : this was adopted to simplify the handling of such materials as hydrochloric acid. The functioning of the dosing unit will be clear from the illustration below : the resin is driven from the pressure container into the right-hand (partly concealed) cylinder, forcing down the swinging link, which pivots about its left-hand end. The piston in the catalyst cylinder, that nearest the fulcrum, draws in a charge from the bucket : the volume displaced by the catalyst piston will be related to that of the resin piston by the position of the catalyst cylinder piston rod along the swinging link. When the spray gun is lifted from its hook valve, compressed air closes valves in the resin and catalyst supply lines and pressurises the lower end of the centre cylinder, driving the link upwards. As it rises, it will displace proportioned volumes of resin and catalyst from their respective cylinders and pass them through flexible hoses to the spray gun. When the nozzle valve of the gun is closed, the pressure in the resin cylinder rises sufficiently to halt the dosing unit, and the flow of catalyst also stops : however, because of the elasticity of the pipe lines, a dribble of catalyst may take place, and in the case of hydrochloric acid this was found to be detrimental to the gun. There is, therefore, a catalyst valve, with a polythene body, on the back of the gun. This valve also can arrest the dosing unit, but the pressure resulting in the hose will be higher in the ratio of the volumes dispensed, and the correspondingly higher volume change would be magnified by the link mechanism, so that dribble from the high volume line would be greater roughly as the cube of the dispensing volume ratio. Nevertheless, when the gun is to be calibrated, it is the resin line which is provided with a bleed valve below the gun : the flow of resin from this bleed and of catalyst through the gun are collected separately and compared. Small adjustments, by means of the screw shown, of the position of the catalyst piston rod can attain the proportions required—the range of the equipment is from 5 per cent to 25 per cent. For demonstration purposes, a white lacquer and a crimson additive were sprayed, and as soon as steady conditions became established, a few seconds after spraying commenced, an even and consistent pink finish was obtained. Material and catalyst cylinder volumes of 500 cc and 200 cc allow about 80 square



Proportioning unit of the catalyst dispensing equipment



Cycle of low temperature unit

feet of spraying before closing the hook valve to recharge the cylinders : a viscosity of No. 4 Ford cup is recommended for the base. On this plant, the catalyst cylinder and fittings were made of p.t.f.e., to allow corrosive liquids to be handled. Apart from a compressed air supply, the equipment is self-contained.

Overhung-Engine Scraper

AN overhung-engine scraper is now being produced in the United Kingdom at the Glasgow factory of Euclid (Gt. Britain), Ltd. This machine, the "Euclid" S-7, has a capacity of 7 cubic yards, or 9 cubic yards if heaped, and is smaller, with a lower power loading, than previous machines. It is driven by a 147 h.p. Leyland diesel with a Fuller five-speed transmission : an interesting detail is the location of the clutch and gearbox behind the drive axle and scraper pivot, so that when full lock is applied they are easily accessible. Steering is by a pair of hydraulic rams, and a 180 deg. range of movement is possible—the 29ft long vehicle can turn about within a 26ft width without stopping, the wheelbase being just under 18ft and the width exactly 8ft.

This overhung-engine scraper is now in quantity production in Scotland

A 1·2 : 1 transfer case passes the power to a 3·78 : 1 limited-slip differential, and in each driven hub planetary gears raise the overall reduction to 20·77 : 1. There is an external contracting brake on the transmission ; each of the wheels, which are cast in alloy steel and carry removable flanges, has a conventional pneumatic brake. All tyres are sixteen ply, 18·00 by 25, or optionally 21·00 by 25; unloaded, the driving wheels carry 7½ tons and the scraper wheels 3½ tons, the payload being an additional 9½ tons.

The scraper is welded up from steel on heavy scantlings. The 14in diameter main torque member carries three hydraulic rams, the outer pair lifting the cowl and the inner one raising the apron by means of a short length of cable. A fourth, interchangeable with the others, drives the ejector.

The maximum speed of the machine is 25 m.p.h. and it can climb gradients of about 1 in 2½ empty and 1 in 3 loaded, the climbing ability being slightly better in reverse than first gear. The gear ratios cover a range of nine to one.

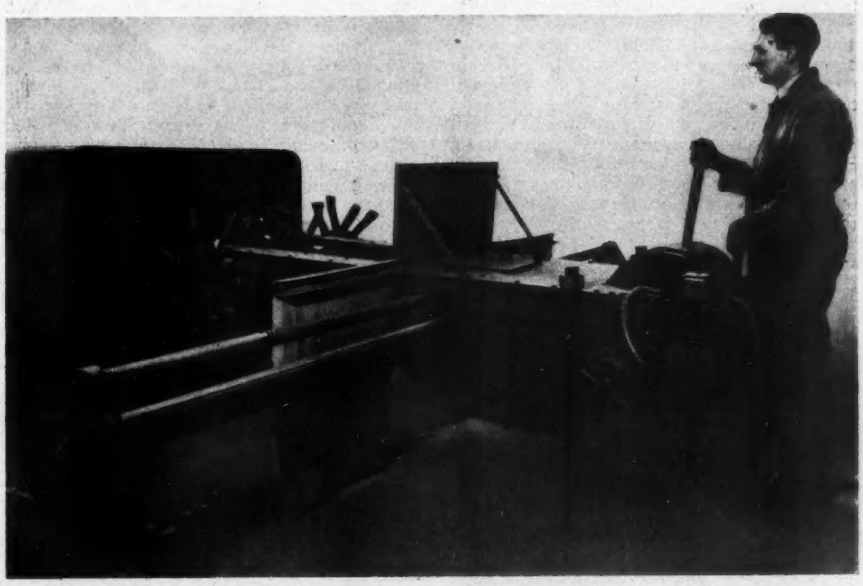
Mine Car Cleaning Plant

THE dirt which collects and adheres to the bottom of mine cars can, in certain cases, build up to an extent which reduces the capacity by an appreciable percentage. The commonly used ways of removing this accumulation of dirt generally involves expensive hand labour or damaging the structure of the cars. To reduce the time and labour expended in this work and provide an effective cleaning method, Humphreys and Glasgow, Ltd., Carlisle Place, London, S.W.1, has acquired the manufacturing rights of a cleaning plant of German design. The range of plant now made by this firm is capable of handling all designs of mine cars, and includes fully powered horizontal cleaners for cars on tippler gear, vertical cleaners arranged for overhead suspension for cars in their normal upright position, pedestal mounted cleaners and hydraulically operated washing plant.

Recently the firm demonstrated one of the horizontal cleaners which is particularly intended for dealing with mine cars which carry the stone used for dust control, where, under wet conditions, the deposit can build up to the consistency of concrete. This machine can be seen in the illustration on this page. It consists essentially of a cleaning machine supported on a heavy shaft carried by pinion wheels at each end on two heavy rack girders bolted to concrete bases. The machine itself is balanced on the shaft and consists of a body complete with the motor drive and having two jibs projecting forwards. At the head of each jib there are two pairs of wire brushes built up of short lengths of old haulage ropes. The weight of the jibs and brushes is balanced by that of the control and drive mechanism in such a way that it can be swung by hand up and down on the main shaft. Above and parallel to the cross shaft is a heavy worm shaft which passes through a nut in the drive unit. The brushes are rotated by chains extending through the box form jibs.

A joystick control lever projecting from the top of the body of the machine engages a series of friction clutches. When the lever is pushed forwards or backwards, appropriate clutches are engaged to rotate the main shaft and, through the racks and pinions at its ends, move the brush jibs into and out of the tub, which is tilted on its side in the tippler in front of the machine. Movement of the lever to the right or left engages other clutches through which the wormshaft nut is turned to traverse the jibs along the length of the mine car. When the brushes are in contact with the dirt deposit in the mine car, the machine can be lifted up and down by the operator to traverse them across the width of the car. The balance of the machine is such that the operator can move the jibs up and down with one hand if necessary, whilst traversing it along the length of the car by operation of the joystick with the other hand.

This horizontal cleaner is driven by a 5 h.p. motor and is designed for cleaning two mine cars at the same time; it is also made in a narrower form for cleaning single cars. To protect the operator from flying pieces of dirt during cleaning, a steel guard plate is fitted in front of the body and provision is made for hanging canvas curtains on each side. When the machine is at rest its body is supported by two legs with a connecting skid plate, which prevents their damaging the concrete base during lateral movement. When the deposit has been loosened the cars are tipped through a further 90 deg. in the tippler to drop the dirt into a hopper below. In cases where the deposit has hardened to such a degree that the brushes cannot free it from the bottom of a car, the brushes can be removed and replaced by rotating pick heads.



Power-driven mine car cleaning machine with horizontal joystick control, used with mine cars tilted on their sides in a tippler

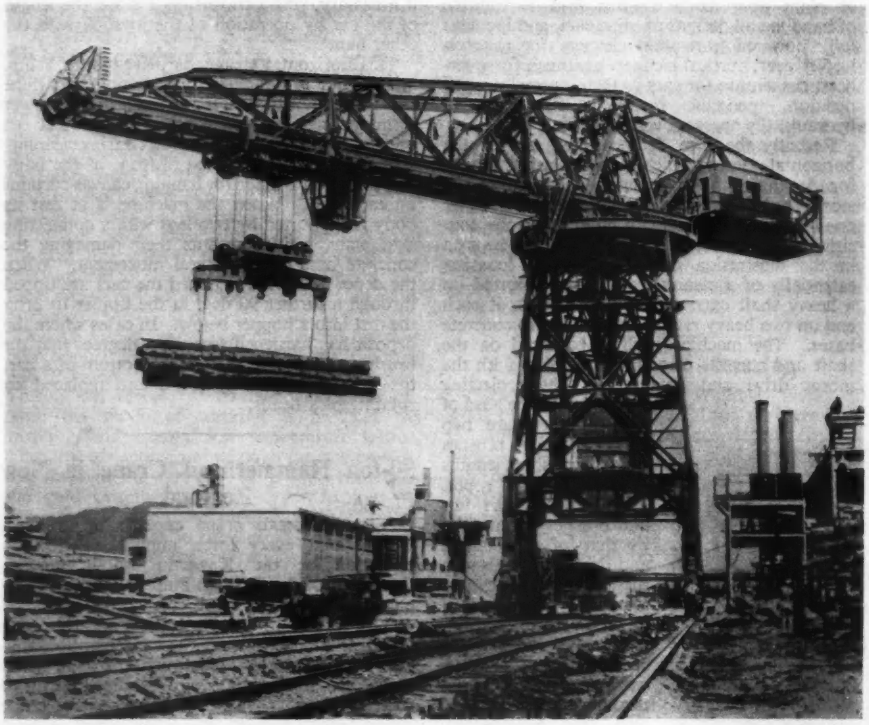
30-ton Hammerhead Crane in New Zealand

A HAMMERHEAD crane capable of lifting a 30-ton load every three minutes is now in operation at the Kawerau wood preparation plant of the Tasman Pulp and Paper Company, Ltd., of Auckland, New Zealand. The crane, shown in the illustration on page 648, is said to be one of the largest in operation anywhere in the world. It is over 80ft high, has a reach of more than 90ft and handles logs up to 40ft in length. The portal tower of the crane straddles two railway tracks on which wagons bring logs to the plant. Bundles of logs are lifted from the wagons and stocked to a height of about 40ft, forming a store of up to 1,500,000 cubic feet of logs on either side.

The portal tower carries a rotating boom, which is about 150ft long and on which is mounted the main winch of the crane. A 150 h.p. motor drives the winch, which hoists loads at automatically controlled speeds up to the maximum of 50ft per minute. The lifting beam, which is suspended from a traversing trolley on the boom, can rotate and an automatic device prevents the slings releasing hold of the logs until they are placed on the stockpile and the crane is relieved of the load.

Total weight of the crane is about 250 tons. It can travel at a speed of 200ft per minute along the store, which rises gradually throughout its length. When the crane is out of operation it is clamped to the tracks by an electrically operated safety device, which keeps it stable in high winds or during earthquake tremors which occur in the area.

The operator is seated in a cabin attached to



Hammerhead crane of 30 tons capacity. The crane, which weighs 250 tons, is capable of lifting a 30-ton load of logs 40ft long every three minutes and can stock to a height of about 40ft

the trolley, and by a system of hand levers and foot pedals controls the six motions of the crane.

The crane was designed, manufactured and assembled by the N.V. Werf Gusto Company, of Holland Cranes, The Hague, and built for the Mitchell Engineering Group, Ltd., London, to the requirements of Sandwell and Co., Ltd., consulting engineers, of Vancouver, Canada.

Proposed Highway Bridge at Perth, Western Australia

THE Government of Western Australia has recently approved proposals for a highway bridge to be completed in the next three years across the Swan River at the Narrows, Perth, in Western Australia. The bridge, which is to be a prestressed concrete structure, is to provide a six-lane carriageway 70ft in width and two pathways, each 10ft in width. The total length between abutments is to be 1100ft, divided into five spans, of which the longest is to be 320ft. An impression of the completed structure is given in the accompanying illustration.

The design has been prepared by the Government's consulting engineers, G. Maunsell and Partners, of Westminster; Sir William Holford and Partners have advised on matters related to the appearance of the bridge, which is considered to be of particular importance in view of the beauty of the setting in which it is to be built. It is expected that constructional work on the new bridge will be started next year.

Design for a five-span highway bridge in prestressed concrete across Swan River, Perth

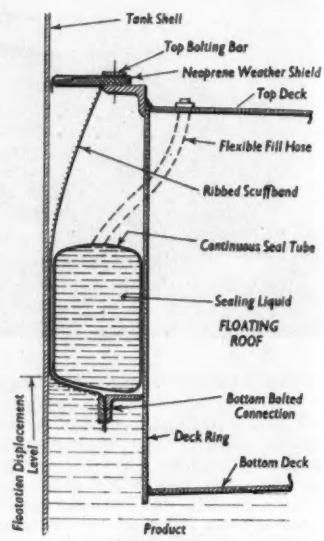
Tubular Rubber Gas Seal

LARGE petroleum storage tanks have always been subject to vapour loss, and to eliminate this loss the Hammond Iron Works, U.S.A., has developed a "Tubeseal" system for sealing floating roof tanks. This particular form of seal is manufactured under licence by William Neill and Son (St. Helens), Ltd., and this company has fitted the system to two 1,000,000 gallons capacity storage tanks, 80ft diameter by 36ft high, at the Coryton refinery of the Mobil Oil Company, Ltd.

There are no moving parts in the sealing system; no mechanical maintenance is required, and the entire circumference of the tank is provided with a tight seal under pressure. Our drawing shows a section through the seal, which is at flotation level so that there is no vapour space in the seal area and vapour cannot form. The ribbed scuff band consists of a butadiene acrylonitrile synthetic rubber coating over a nylon backing having a total thickness of $\frac{1}{16}$in, and the tube has a base fabric of nylon coated on each side with synthetic rubber to give a total thickness of 0·04in, providing a minimum strength of 130 lb per lineal inch of circumference. Both the scuff band and tube are made in one piece and have no cemented or sewn seams, and the material has a temperature operating range from minus 20 deg. to 200 deg. Fah.

The tube is generally filled with kerosene or light oil or brine; by filling under slight pressure a centering action is applied to the floating roof, and the liquid also distributes a compensating pressure over all irregularities of the tank shell. About 8in width of seal surface is in complete contact with the tank shell and forms a continuous flexible and positive seal. Many wiper contact surfaces are provided by the ribbed design of the scuff band, so that the shell is wiped dry as the level of the contents of the tank is lowered, and these ribs by forming an irregular vertical line prevent any capillary action so that there will not be any "wicking" losses. The seal pulls away from a frozen area with a peeling action; this permits movement of the roof with an increment of seal without requiring the entire contact surface to slide at one time and eliminates the possibility of freezing up. This form of seal, it is claimed, will not be damaged by sand, scale or rust, will not abrade any tank internal coating and is not affected by sour crudes.

Oil-resistant rubber compounds tend to deteriorate under prolonged exposure to sunlight, and to protect the sealing band from the sun's rays there is a neoprene weather shield, which also serves to prevent airborne dirt and rust from entering the tank. Inspection of the scuff band contact surfaces can be effected by folding back the weather shield, and the tube can be inspected while the tank is in use by unbolting a section of the top bar and unhooking a length of the top edge of the scuff band.



Section through floating roof and tank shell at sealing ring

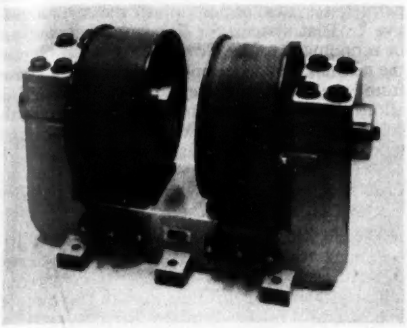
A steel rod extending from the tank bottom through a packing gland in the roof prevents the roof from rotating. Any build-up of static electricity in the roof, owing to it being insulated from the shell by the seal, is avoided by the fitting of an internal copper cable to connect the roof with the tank bottom, while the rolling ladder and gauging devices act as other means of discharge. The manufacturers claim that the seal has a life equal to that achieved when using metal shoes, and that the initial cost is no more than for a metal shoe installation, while replacement cost is less.

Laboratory Electromagnet for Research Work

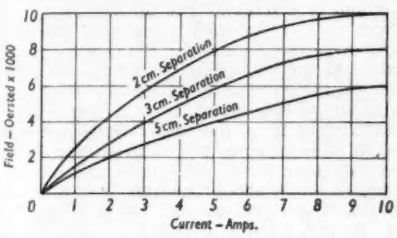
WE illustrate an electromagnet which is intended primarily for basic research and is made by Newport Instruments (Scientific and Mobile), Ltd., Newport Pagnell, Bucks. Magnetic field strengths up to 10,000 Oersteds are stated to be attainable at a 2cm separation of the pole pieces, with a current of 10A, as indicated by the accompanying performance curves.

Normally the yoke is of cast iron, the pole

pieces being machined from mild steel, but components made from other materials can be supplied. The pole pieces have plain tips of 10cm diameter, but conical or angle tips are available. The excitation coil bobbins are fabricated from brass, lined with 0·032in thickness of resin-bonded insulating fabric and then wound with double-glass-insulated wire. "Tufnol" tubes provide mechanical protection for the connecting wires. Each coil is wound



Laboratory electromagnet designed to produce field strengths up to 10,000 Oersteds



Coils in parallel, cooling by natural convection.

Approximate performance of electromagnet with 10cm mild steel pole pieces

with about 3550 turns of 0·064in wire, giving a resistance of 17·5 ohms. Cooling is by natural convection and the maximum continuous current that can be carried by the coils in parallel is 8A, giving a continuous dissipation of 600A.

The electromagnet is 27in long by 12in wide by 17in high and it weighs 5½ cwt.

Aircraft Silencing Pen

We recently attended a demonstration of a ground running enclosure for "Javelin" fighters at the Hucclecote aerodrome of the Gloster Aircraft Company, Ltd. The noise of the two "Sapphires" of each production aircraft being ground tested had been unpopular with those living nearby, and also distressing to those working in the factory. The construction of the pen allows ground running to be carried out immediately adjacent to the hangars without obtrusive noise.

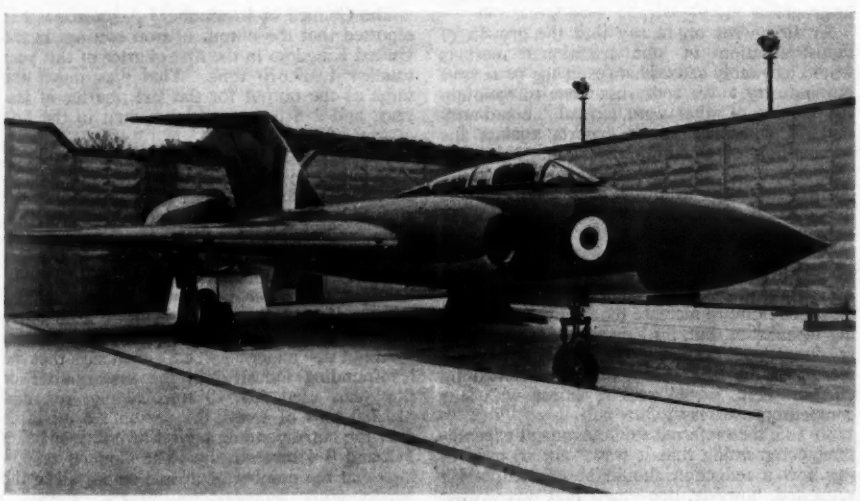
The two jets discharge into a 76ft long detuner. The flared intake is followed by a short oval section, and then opens to a large circle with double walls, the inner shell being perforated and the intervening space filled with acoustic material. A set of adjustable vanes is provided to increase mixing of the engine exhaust with the air entrained into the detuner, and thereby lower the peak temperature of the gas. At the outlet from the detuner a cascade turns the air into a short vertical open exhaust stack.

The designer of the installation, the late Mr. Quentin Reeves, did not consider the detuner alone adequate, since it is not possible to bring it right up against the tail pipes without altering the conditions of the ground run, and moreover a proportion of the acoustic energy is passed into the airframe and radiated from the structure. The aircraft has accordingly been surrounded with a concrete-cored double brick wall, 16ft high, and a set of sliding steel doors. The pen was not roofed, since an unsupported span of about 70ft subjected to very high noise energy inputs was not an inviting proposition, while the noise inside the enclosure might have become intolerable. The inner faces of the walls and doors have been surfaced with glass wool, retained by rot-proof canvas and covered by perforated aluminium sheet. This is believed to have reduced the noise to which the ground crew are subjected by 8 decibels.

The reduction in noise outside the pen is of the order of 40 decibels. The aircraft, we are informed, is inaudible 2 furlongs away, while one found it possible to converse without strain immediately outside the wall.

The aircraft is backed into the pen along two white lines that lead to the chocks for the main wheels. Each chock is shaped to fit the tyre and held to rails in the concrete floor by a heavy shear pin. Nevertheless, the chocks weigh 5 cwt each, and a manual lifting trolley is used to handle them. A support hinged to the floor astride the nose wheel swings forward to intercept the upper portion of the nose leg and prevent it compressing as the engines are run up, while a tie under the after fuselage suppresses any tendency for the main undercarriage to extend. Starting in the "Javelin" is by slow-burning cartridges, and consequently no service leads are provided in the enclosure. Fire-fighting equipment is kept inside, and small wooden doors allow ground staff to enter and leave.

The silencing pen is designed to be adaptable to larger or more powerful aircraft that may be built at Gloucester in the future.



A Gloster "Javelin" in the silencer pen at Brockworth; the chocks for the main wheels and the support for the nose leg can be seen. A well for the nose wheel diminishes the large ground angle of the delta

Projects in Tasmania

FROM A CORRESPONDENT

Giving evidence before the Commonwealth Grants Commission, on February 28th, the Director of Industrial Development, Mr. A. G. Langton, outlined a programme of projects now being discussed in Tasmania. He said that the future of industrial development in the state might hinge largely on the growth of the aluminium industry. Evidence supported the economic case for the establishment of rolling mills and associated industries in Tasmania, in conjunction with the Aluminium Production Commission at Bell Bay. Conversion of ingots into sheets, pipes and bars was carried out in Australia, mainly by two Sydney firms.

The present Australian consumption of aluminium and aluminium alloy products of all kinds was 10,500 tons, or 3 lb per head of population. In the United Kingdom it was 13½ lb per head per annum. The consumption in Australia was, therefore, low by world standards and revealed a future probable large-scale expansion. Increases were likely in many fields. Architects had plans for city buildings with structural aluminium possessing the same tensile strength as steel with about a third of the weight.

Other outlets were in prefabricated buildings, aircraft, passenger transport, railway rolling stock, domestic appliances, irrigation tubing and corrugated roofing sheets (used very extensively for bungalows and housing estates).

Electrical power represented a substantial proportion of the manufacturing cost of aluminium, and from this aspect it would be more economical for rolling mills and allied industries to be set up in the state providing the most abundant and cheapest power.

Mr. Langton then discussed the outlook for other industries in the island. There were, he said, prospects of at least eight new industries in Tasmania, including an iron and steel potential. The Government was endeavouring to attract British and foreign interests to Tasmania to set up an iron and steel industry. Large deposits of high-grade iron ore had been located on the north-west coast and results of preliminary surveys and other technical information had already been supplied to overseas interests.

In Australia this year steel consumption would reach roughly 2,000,000 tons, the local production being only 1,700,000 tons. By 1960 the annual consumption of steel was estimated to reach 2,500,000 tons. Should the Tasmanian iron ore deposits be found suitable, there was an excellent chance that the industry would change the economic future of the state.

Applications for assistance to be considered during the next financial year included increased shipbuilding facilities at Devonport, the manufacture of insecticides by a New Zealand firm merging with a British company; manufacture of aluminium household goods; producing specialised paper products; prestressed concrete products, and extension of rayon manufacture. All these projects visualise new factories in Tasmania.

There had, said Mr. Langton, been a rapid change in the balance of economic development in Tasmania since the war. Between 1947 and 1954 the population had risen by 20 per cent, the working population had increased by 18 per cent, the value of production from secondary industries rose by 267 per cent to £A33,000,000; primary production increased by 148 per cent.

The Electrolytic Zinc Company's project to manufacture sulphate of ammonia had now reached its final stage and it was expected when the full power of 30,000 h.p. had been provided that some 55,000 tons of sulphate of ammonia would be produced each year, sufficient to satisfy about half the present Australian demand.

With the completion of electricity projects, the installed capacity of power in Tasmania would, by 1960, reach 800,000kW.

"British Chemical Engineering."—We have received the first issue of *British Chemical Engineering*, a monthly journal published by Heywood and Co., Ltd., Drury House, Russell Street, W.C.2. It contains articles on a variety of subjects, ranging from automatic monitoring of viscosity to the selection of fluid-flow valves, and including less technical matters such as the work of William Perkin and the status of the pilot plant.

Industrial and Labour Notes

Wage Rates

The Ministry of Labour has stated that changes in wage rates which became effective during April resulted in an aggregate increase of about £1,191,000 in the weekly full-time wages of 2,856,000 workpeople, and in a decrease of £3000 for 31,000 workpeople. The decreases, which affected workers in the carpet making industry, operated under sliding scale arrangements based on the index of retail prices.

Among those who received wage increases in April were building and civil engineering contracting workers, whose rates were raised by 2½d. an hour for craftsmen, labourers and women operatives. In the engineering and allied industries women workers received an increase of 8s. 6d a week, with corresponding increases in piecework rates. Semi-skilled and unskilled workers who are paid on miscellaneous "M" rates in many Government industrial establishments, received increases in their minimum rates amounting to 4s., 7s. or 10s. a week, according to district, for men, and to 3s. 4d., 5s. 10d. or 8s. 4d. for adult women workers. Another change in April was in the statutory minimum rate fixed under the Wages Councils Act for workers employed on goods transport by road ; it was increased by 9s. a week for all workers over twenty-one. A new classification for drivers of vehicles of over 18 tons carrying capacity has also been introduced, providing a differential of 5s. above the rate for vehicles of 15 to 18 tons.

In the first four months of this year the Ministry of Labour says, changes in wage rates led to an aggregate increase of £5,126,400 in the full-time weekly wages of about 10,222,000 workpeople in the United Kingdom. In the comparable period of last year there was a net increase of £3,518,000 in the weekly full-time rates of 9,058,000 workpeople.

Wage Claims

At the end of last week it was stated that the Associated Society of Locomotive Engineers and Firemen had decided to ask for a wage increase of 15 per cent for its members employed by British Railways and London Transport. This decision, it is understood, was taken at the Society's annual delegate conference. The workers concerned are approximately 70,000 drivers, firemen, motor men and engine cleaners. It will be recalled that they, in company with other railway workers, had their wages increased by about 7 per cent on January 23rd last.

A statement on wage claims was made by the Engineering and Allied Employers' National Federation on Thursday of last week, following a meeting of its management board. This statement announced the board's decision that further wage demands from the engineering unions would be rejected. That decision, the statement added, had been taken in view of the national inflationary position, and in view of the fact that a wage increase was granted in March. It will be recalled that at the recent annual conference of the national committee of the Amalgamated Engineering Union a resolution was passed calling for a " substantial increase " in wages.

Automation and Cost Accounting

Last week-end, the Institute of Cost and Works Accountants held its twenty-seventh annual conference at Edinburgh. As was to be expected, there was a good deal of emphasis in the discussions on the impact of automation upon industry. The two papers presented at the conference were " The Impact of Automation on Management Accounting," by Mr. David Young, and " Looking Forward," by Mr. R. W. Duffield.

In his address to the conference, the retiring president, Mr. George Nicholson, said that there had been so much talk about the need to increase productivity that the nation could not claim that it had not been warned. If the warning was not heeded, it would have to be concluded that the population of this country just did not intend to bestir itself, and was quite content to go downhill. There had been enough talk, Mr. Nicholson commented, and the crying need to-day was for action.

Some seemed to think, Mr. Nicholson continued, that the answer was a new industrial revolution, and that all our problems would be solved overnight by automatic machinery. That, he considered, was complacency at its worst. Automatic machinery was nothing new, Mr. Nicholson pointed out, for it had been gradually developed over many decades. It had already contributed to increased production, but the process of developing such machinery had not by any means reached its limit. To-day, Mr. Nicholson said, there was a wide variety of labour-saving tools and machinery available, and the parallel development of electronic devices in conjunction with them was enabling even greater production without additional labour. This development had acquired the title " automation." About it, Mr. Nicholson observed, there had been a lot of uninformed comment, some creating widespread consternation, and other seeming to promise an even lazier life for industry with talk, not of more production, but of shorter working days and a shorter working week. If the latter view prevailed, Mr. Nicholson asserted, it could hardly be, in the short run, a cure for our present problems.

Industrial Disputes

During April there were 237 stoppages of work through industrial disputes in the United Kingdom reported to the Ministry of Labour. In addition, nineteen stoppages which began before April were still going on in the early part of the month. The Ministry of Labour says that on account of these 256 stoppages, there was an aggregate loss of 143,000 working days in April by the 55,400 workers concerned in them. There were 234 stoppages which ended during April ; of that number, ninety-seven, involving 14,000 workers, lasted for not more than one day. In the first four months of this year, there were 954 work stoppages through disputes, involving 222,900 workers and causing an aggregate loss of 799,000 working days.

Taxation and Inflation

In his presidential address at the annual general meeting, on May 31st, of the Association of British Chambers of Commerce, Sir Eric Carpenter spoke about the necessity to stimulate cost consciousness in industry. Sir Eric said that he welcomed the additional incentives to saving provided in the recent Budget, and, above all he welcomed the Government's determination to reduce expenditure by at least £100 million. He was convinced, he added, that the crushing burden of taxation being carried in this country was the root of many of the difficulties retarding its progress.

Sir Eric went on to say that the growth of industrialisation in our traditional markets would inevitably cause changes in the pattern of our industry. We could not hope to maintain the volume of what were termed " bread-and-butter " consumer goods exports against the competition of the low wage countries. The adaptation of our industries to meet those changes and the changes occasioned by the introduction of new methods of production, Sir Eric commented, would call for the investment of considerable risk capital, and the present level of taxation afforded little incentive for that. The Government was commendably embarking on expenditure to increase the facilities for training technicians, but, Sir Eric asked, were we not in danger of producing technicians who, by reason of the lack of incentive occasioned by taxation here, would seek a career with our competitors overseas ?

Sir Eric then referred to Government expenditure, commenting that it was " not so easy to say how a reduction should be effected." He suggested, however, one aspect that was worthy of study, not only from the point of view of reducing Government expenditure, but of stimulating cost consciousness in extensive fields of industry. It would be irresponsible to urge, Sir Eric said, on grounds of economy, a reduction in defence measures, but it was surely necessary to our economic welfare that the strictest economy be exercised in their cost. He appreciated that the system of competitive tendering could not be applied in every case, but was the pernicious system of " cost plus " the only alternative ? That system, Sir Eric argued, could not be economical to the Government and it blunted the resistance of the supplier to increases in costs from whatever cause they arose. We could ill afford the consequences in the industries directly concerned, Sir Eric remarked, and their inevitable repercussions on our industry as a whole.

Cost Increases in the Agricultural Engineering Industry

The Agricultural Engineers' Association has been analysing and forecasting cost increases throughout the British agricultural engineering industry, and comparing them with those of the U.S.A. and Western Germany. This analysis has been made from information provided by member-firms of the A.E.A. on costs of materials, wages, fuel and power and transport.

The forecast made for the first quarter of this year and beyond, it is stated, proved to be accurate ; it revealed a small increase, of the order of 3 per cent, compared with the corresponding period of 1955. But while last year costs during the second quarter rose by two points, the increase estimated for the second quarter this year is more than double. During the first quarter of this year, there was virtually no increase in the cost of materials, but for the second quarter the A.E.A. estimates that the increase will be about 6 per cent, compared with 1955. Wages and salaries rose by 1 per cent in the first quarter of this year, and the rise expected for the second quarter is even greater than for raw materials. Furthermore, fuel and power costs are expected to show an increase of between 1 and 2 per cent, and outward freight costs are likely to be between 5 and 6 per cent higher than in the comparable quarter of last year.

A statement by the A.E.A. says that an examination of industrial earnings and output reflects " the comparatively unfavourable position in which our economic policies have landed us." The only consolation, it is added, is that wage rates in Germany and the U.S.A. are also advancing rapidly ! But this factor has had no unfavourable effect on United States exports of agricultural machinery. In March, they were 15 per cent higher than in the corresponding month last year, while this country's were only 5 per cent higher.

Iron Castings Production

The Council of Ironfoundry Associations has reported that the output of iron castings in the United Kingdom in the first quarter of this year totalled 1,039,670 tons. That was much the same as the output for the last quarter of last year, and 2·6 per cent higher than in the first quarter of 1955.

Commenting on the first quarter's activities, the Council says that the output of ingot moulds continued at the high level reached towards the end of last year. The production of cast iron pipes, and castings for the engineering and railway industries, continued to increase in the first quarter. The production of automobile castings, however, was 6 per cent lower than in the final quarter of 1955, though it was still a little above the level of the first quarter of last year.

About raw materials, the Council says that the ironfounding industry, in the first quarter of this year, used 657,510 tons of pig iron and 820,380 tons of scrap, the percentage increases over the corresponding period of last year being 1·2 and 0·4 respectively. The Council reports also that the number of people employed in the ironfounding industry on March 31st was 145,444, which was 659 less than at the beginning of the quarter. Some decline in the labour force is normal at that particular time of the year.

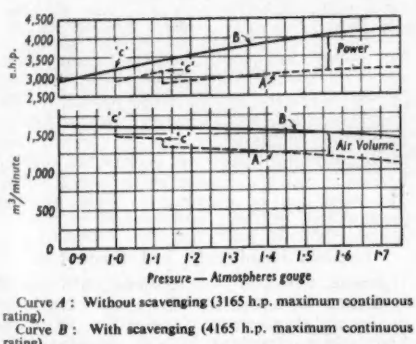
Reconstruction of Large Gas Engines

THE rebuilding of the August-Thyssen-Hütte steelworks at Duisburg-Hamborn presented an opportunity to overhaul and modernise a number of large gas engine-driven blast-furnace blowers. The work, which was carried out by Siemag, of Dahlbruch, resulted in an increase in output of 25–30 per cent. This improvement was achieved by the addition of a scavenging and supercharging system, without increasing the engine speed.

Fig. 1 shows the reconstructed units, which are

Fig. 1—Ten gas engine-driven blowers for blast furnaces, modified to include scavenging blowers

ten in number. When first installed they were generating a lower air pressure than is usual at the present time. Consequently the cylinder diameters were relatively large, so as to make full use of the available gas engine power. The higher air pressures which are employed nowadays would have necessitated a reduction in the cylinder diameter of the blowers. With the improvement in output of the gas engines which was obtained, not only was it found possible to operate the existing blowers at the higher pressures, but to have a certain reserve of power in hand. Fig. 2 shows what has been



Curve *A*: Without scavenging (3165 h.p. maximum continuous rating).
Curve *B*: With scavenging (4165 h.p. maximum continuous rating).
At "*c*" clearance pockets of blower are opened to reduce output.

Fig. 2—Increase in blower output obtained by adding scavenging blower

achieved in terms of power and volumetric output at the various pressures.

In the rebuilt machines the scavenging blower was fitted in place of the back guide of the main blower piston rod. This increased the length of the unit by about 5ft. Changes to the piping to connect the charging blower to the existing air inlet were simple and straightforward, and alterations to the engine foundations were small. It was necessary to lengthen the main blower piston rod. This was done by shrinking on a sleeve. The blower piston was screwed to this extension.

In addition to renewing the inlet valves and their control gear, the mixing chambers at the inlet, together with the built-in mechanism for regulating the air/fuel ratio, were replaced by a modified design. Another alteration made was to the adjusting devices for the governors of the gas engines and the blowers which were arranged for operation from one central point by means of remotely controlled oil servo-motors.

The scavenging system here adopted is stated to render superfluous the use of a special mixed air inlet pipe through which air might be aspirated directly from the atmosphere. It was found that for blast-furnace gas with its low calorific value such a mixed air suction line could be dispensed with.

With the "two-channel" system, where one inlet channel is for gas and the other for air, the existing lines for gas and air remained almost unchanged, although the air was supplied under a slight pressure of about 5 lb per square inch gauge.

The greater proportion of the remarkable increase in output was due to the thoroughness of the scavenging of the compression space which comprised about 20 per cent of the total chargeable volume of the power cylinder. In such cases a complete scavenging of this space and filling it with a fresh mixture can by itself theoretically give a 20 per cent rise in output.

The cooling effect of the scavenging air was an important factor in this improvement, the more so since in the Siemag design there is plenty of time available for the air to enter the cylinder and expel or carry away the exhaust gases before the beginning of the next charging stroke. For admitting scavenging air, the inlet valve is opened by a small amount for the largest part of the exhaust stroke. Only during the following suction stroke is the inlet valve opened fully so as to uncover the gas inlet ports. Regulators for gas and air are built into the inlet passages. The opening of the inlet valve in stages, which is an essential part of the system, can only be carried out, it is stated, by using cams for operating the valves. Valve governing with eccentrics, on the other hand, is said to shorten the available scavenge period considerably.

An additional charge and a consequential increase in power can be achieved by introducing a boost of air at the end of the charging stroke.

The possibility of operating temporarily without scavenging has purposely been neglected, for it was thought that to do so would lead to unnecessary complications and prevent really effective scavenging.

Tests are stated to have shown that at top output, mean gas pressures may reach 100 lb per square inch, depending, of course, on the calorific value of the fuel gas, operating conditions, and the state of the engine. Engine manufacturers generally assume a continuous output far below these top figures, so as to maintain a sufficient power reserve and to ensure reliable operation at all times, with a high safety margin against spontaneous ignition. Under these conditions the mean gas pressure lies at 75 lb to 80 lb per square inch, which is still 15 per cent below the possible maximum, but compares favourably with the mean pressures of 60 lb to 65 lb per square inch which are obtained with many obsolete engines without scavenging.

By giving each engine its own built-on charging blower, it was found possible to proportion the combustion and scavenging air correctly under all conditions of operation. Mainly for that reason, the rebuilt engines had a speed regulation which was almost as good as that of a steam engine. It was found possible to reduce the engine speed temporarily from 85 r.p.m. to 18 r.p.m. under full load, without the engines stopping or any ignition failures occurring.

There is said to be no danger with this system of "drowning" the engines with gas at low speeds. It is therefore possible to equip these engines, when driving blowers, with automatic speed regulation which previously was thought to be inadvisable with four-stroke engines of the orthodox design. By proportioning the charging air by means of the charging blower, the engine in fact attains some of the qualities of the two-stroke gas engine, which is known for its quiet operation at low speed and for that reason is often preferred as a prime mover for blowers.

The August-Thyssen-Hütte has always been careful about making good use of the waste heat from its gas engines. Previously the exhaust piping and its insulation created some difficulties, owing to the high temperatures of over 1500 deg. Fah. which had to be dealt with. These troubles are also eliminated now, for in spite of the higher specific output of the rebuilt engines, the waste gases leave the power

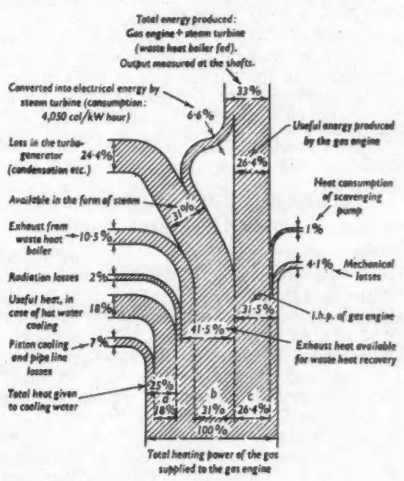


Fig. 3—Heat balance of gas engine with scavenge blower

cylinders at about 1000 deg. Fah., or only slightly more. The life of the waste gas pipes is additionally improved by a cooling system connected to forced circulation waste heat boilers of the La Mont design. This cooling system reduces the exhaust temperatures by a further 200–300 deg. Fah.

There has also been installed for a considerable time a system of utilising the waste heat in the cooling water from the power cylinders, by

cooling these cylinders with hot water and using the output for space heating. Since in twenty-four hours the quantities of heat from this source amounts to some 400 million B.Th.U., the first cost for the additional plant required was recovered in a very short time. The heat balance of a Siemag four-stroke gas engine with scavenging, shown in Fig. 3, indicates ways in which waste heat can be recovered. For cooling with water at 160–170 deg. Fah., cylinders fabricated from mild steel are used in which a thin liner is directly cooled by welded-on coils. The consequent improvement in convective heat transfer makes up for the lower temperature drop, so that cylinder lubrication is not impaired.

International Cybernetics Congress at Namur

The Province of Namur is organising, under the patronage of the Ministry of Education and of UNESCO, an International Congress of Cybernetics, which will be held at Namur from June 26th to 29th. The Congress will be presided over by Professor Georges R. Boulanger, of the Polytechnic Faculty of Mons and of Brussels University. The object is to present for general consideration the new ideas which are developing under the overall term of "Cybernetics," and to bring into relief the applications already made of this young science, which is beginning to transform industry very profoundly and, it is thought, will in due course affect most human activity.

The agenda will be divided into four sections, covering both the scientific and the technical aspects of the subject. These sections will be as follows :—"Principles and Methods of Cybernetics" (chairman, Professor P. Auger, Sorbonne and UNESCO), "Semantic Machines (for Computing, Translating, &c.)" (chairman, Dr. L. Couffignal, Inspector-General of Education and Director of the Automatic Computations Laboratory at the Institut Blaise Pascal, Paris), "Automation" (chairman, Professor G. R. Boulanger), "Cybernetics and Life" (chairman, Dr. W. Grey Walter, Director of the Physiological Department, Burden Neurological Institute, Bristol). The programme of each of the four sections will include an introductory lecture given by the chairman of the section, the reading of papers by members of the Congress, and a general discussion.

A section of the Eighth "Exposition Officielle" of Namur will be devoted to machinery related to the various subjects which are to be discussed. A special programme will be arranged for those accompanying the participants at the Congress. Those interested are invited to write to the Secrétariat du Congrès Internationale de Cybernétique, 13, rue Basse-Marcelle, Namur (Belgium).

Technical Information Services in Germany

The report has now been published* on the second meeting of technical information officers held from May 2nd to 6th, at the Rationalisierungskuratorium der Deutschen Wirtschaft (R.K.W.), in Frankfurt/Main. The conference was attended by delegates from twelve different countries and enabled them to gain an insight into the technical information services available in Germany. It also afforded an opportunity for the discussion of current and future projects of the European Productivity Agency in the field of technical information. The meetings were made more effective through the participation of representatives from different groups of users of the R.K.W. information services, and delegates were able to visit the information departments of the Badische Anilin- und Sodafabrik (B.S.A.F.) and of the Deutsche Gesellschaft für Chemisches Apparatewesen (Dechema).

The R.K.W., which has a headquarters staff of seventy-five and, in addition, about fifty employees in its district groups, is the successive organisation to the Reichskuratorium für Wirtschaftlichkeit which was founded in 1921 and dissolved in 1945. The present R.K.W. was established in 1950 and is a non-profit making organisation with a board of some thirty-five members, drawn from industry and commerce, industrial and trade associations, labour unions, and individual companies. It is supported financially by members' subscriptions and government and F.A.O. subsidies, and has four departments, concerned respectively with German group liaison, international productivity research and information, publication and public relations, and internal administration. The work is carried out through regional groups and associations, and also by means of working groups covering certain fields such as the building industry, management, materials handling, human relations, standardisation, and others.

Among the groups co-operating with the R.K.W. in certain specific fields are the Committee of German Plant Engineers (A.D.B.), the Committee for Fuel Efficiency (A.W.K.), the Association of German Engineers (V.D.I.), the Committee for Efficient Production (A.W.F.), the German Standards Committee (D.N.A.), and the Organisation for Time and Motion Study (R.E.F.A.), and the German Association for Management, which has a counterpart in the form of the management group within the R.K.W. The function of R.K.W. in relation to all of these is that of a clearing house for information and a co-ordinating body. It was stated that up to the beginning of last April, some 10,000 inquiries had been received, of which about 2000 had been original. Users were charged at the rate of DM.10 per inquiry, the cost of which to the R.K.W. averaged around DM.50.

Of other information inquiries, the German Society for Documentation (D.G.D.), has some 200 members and maintains a number of committees and working parties, each of about twenty to thirty members, such as the committee for documentation methods, the committee for the use of mechanical means of documentation, the committee for the introduction of new photographic and other methods of reproduction, and the committee for the training of personnel for documentation centres. D.G.D. publishes a bulletin containing complete details of the German documentation services, which were said to number about 145. In the field of mechanical engineering, special mention must be made of the documentation service set up in 1954 by the Association of German Mechanical Engineering Firms (V.D.M.A.). Efforts are being made to establish an international organisation for mechanical engineering and to extend co-operation with other O.E.E.C. countries.

The importance of information in the patents field was brought out in one of the talks given at the conference by the head of the Information Services of the German Patents Office, Berlin. This service was established in 1949 in order to assist inventors with information about existing patents in their respective fields, as it had been found that only 35 per cent of all German patent applications on examination proved to be sufficiently original for a patent to be granted.

German Atomic Ships

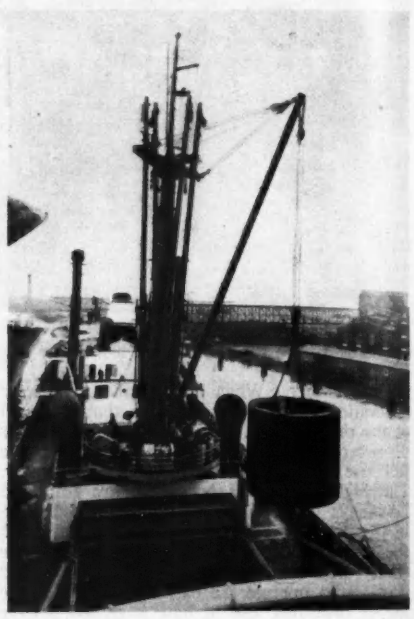
At a meeting in Hamburg, Franz-Josef Strauss, Federal Minister for Atomic Questions, stated that the Federal Government would give financial support to the building of atomic ships in the federal states of Hamburg, Schleswig-Holstein, Lower Saxony and Bremen. Also, he said, it was planned to establish an institute in Northern Germany for research on the construction of reactors for ships and aeroplanes. Minister Strauss furthermore announced that, upon his request, the Budget Committee of the Bundestag had allocated the first DM 300,000 to the "Society for Promoting the Utilisation of Nuclear Energy in Shipbuilding and Navigation" (Gesellschaft zur Förderung der Kernenergie-Verwertung in Schiffbau und Schiffahrt), which was founded on April 18th last.

Continuous Casting of Steel

An agreement has been reached between Concast S.A., Zürich, and Schloemann Aktiengesellschaft, Düsseldorf, entitling Schloemann to build in England and numerous other countries continuous casting plants according to the patents of the Swiss company. Concast continuous casting plants for steel have been in operation for a number of years in England, Canada, France, Sweden, Italy and Japan. It is thought likely that similar plants will be installed in the near future also in Germany, Austria, Switzerland and the Netherlands. According to an announcement made by Schloemann Aktiengesellschaft, models of continuous casting plants are to be shown at the Foundry Exhibition in Düsseldorf, German Federal Republic (September 1–9, 1956), and at the Third International Technical and Industrial Exhibition in Charleroi, Belgium (September 20 to October 1, 1956).

Motorship "Bischofstor"

The motor freighter "Bischofstor," of 8487 gross register tons, built by Nordseewerke Emden G.m.b.H., for Schlüssel Reederei D. Oltmann and Co., Bremen, embodies some novel details of design. With a capacity of 12,100 tons deadweight the ship is equipped with a Borsig-Fiat Model 687T engine of 4200 h.p., 125 r.p.m. and with an Escher-Wyss variable-pitch propeller. When fully laden the speed is 13·6 knots, or 14·9 knots in ballast. Our illustration shows the main mast, which can be rotated together with its hoist platform and machinery.



The main mast of M.S. "Bischofstor" (8487 gross tons), which can be rotated together with the winch platform, so as to serve two main hatches

The 39-ton derrick can be slewed through 235 deg. and in this manner it can serve two main hatches, or approximately two-thirds of the holds of the vessel. The weight of the mast and its machinery, amounting to about 87 tons, is carried by a thrust bearing on the lower deck, while a roller bearing at winch level takes up the lateral forces. The mast can be operated in eight different positions.

German Handicrafts and Trade Fair

Besides 1634 German exhibitors, 616 foreign exhibitors from twenty-six countries took part in the eighth German Handicrafts and Trade Fair, which closed at Munich on May 10th. The fourteen halls covering a total space of about 400,000 square feet were occupied by the twenty-six main groups of exhibitors, of whom 68 per cent represented handicrafts enterprises, while the remainder represented supplying industries. From the point of view of the space covered, the biggest groups were those exhibiting machines, tools, utensils and workshop equipment. The theme of this year's fair was "Rationalisation," which was illustrated in a number of special shows. The number of visitors was 322,000, an increase of 24 per cent over 1955.

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Electro-Mechanical Accounting Machines at the Bank of America

BY OUR AMERICAN EDITOR

Five years of research and development have led to the recent completion of a revolutionary electro-mechanical accounting machine which is capable of handling all the book-keeping functions required to service up to 32,000 accounts maintained at the branch of a bank. The machine is known as "ERMA" (Electronic Recording Machine, Accounting) and was developed by the Computer and Control Systems Laboratories of the Stanford Research Institute for use in the branches of the Bank of America in California.

THE Bank of America, which is the largest private bank in the United States and has branches throughout California, recently commenced the installation of "ERMA" electro-mechanical accounting machines to service its deposit accounts. The machine was designed and constructed for the Bank of America by the Computer and Control Systems Laboratories of the Stanford Research Institute, Menlo Park, California, under the direction of Thomas H. Morrin. In the course of its work "ERMA" credits individual accounts with deposits, debits withdrawals, remembers details of all transactions, maintains correct balances, accepts "stop-payments" and "hold" orders, prevents overdrawing of accounts, and sorts cheques. The machine verifies each accounting step automatically, and virtually any error is immediately signalled to the operator. Parallel processes are provided to ensure accuracy, and each step must be found correct before the next one begins. There is an overall balancing at the end of each day, as well as a monthly recapitulation.

Technically, "ERMA" has been designed to incorporate recent progress in "electronic brain" computers. Its high degree of book-keeping efficiency is made possible by a wide range of developments in magnetic recording, machine reading of printed codes, and techniques of mechanical paper handling and high-speed printing. In addition to the major problem of visualising the complex system required to handle the bank's accounting system, there was an even larger task in making the components of the system function together. In working out the many details necessary, several specialised problems were overcome. Working together, mechanical and electrical engineers of the Institute devised methods of handling cheques of several sizes and weights—even when badly mutilated. Systems were evolved for reading codes and actual Arabic characters printed in magnetic ink, as well as for the development of the ink itself. These systems facilitate the reading of characters with freedom from errors due to poor registration or overprinting.

"ERMA" includes more than 1,000,000ft of wiring, 34,000 diodes, 8000 vacuum valves, and weighs about 25 tons. It uses 80kW of electricity and is equipped with an air conditioning system. The first "ERMA" machine was moved to San Jose, California, early this year to handle accounts for branches of the bank in the San Jose area. The Bank of America will need about thirty-seven "ERMAs" to serve its branch banks throughout California.

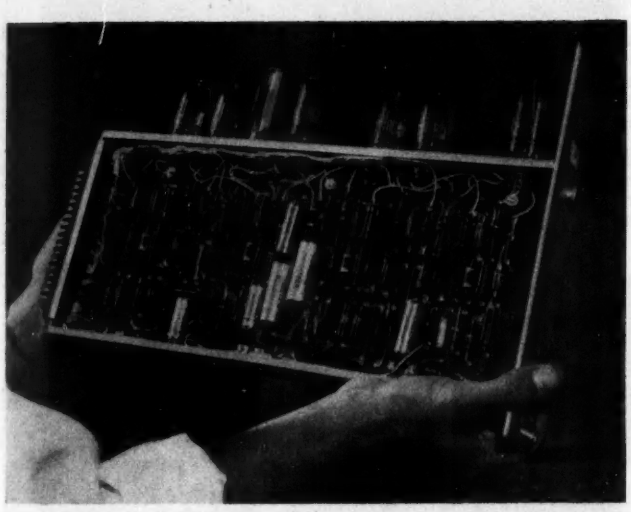


Fig. 1—Representative "building block" panel section of "ERMA" arithmetic unit comprising electronic circuits and vacuum valves

Input of Information

The input keyboards may be considered as the eyes and ears of "ERMA." There are five of these, each resembling a large adding machine. The keyboard is the means by which the system receives information. There are keys to represent the account number, branch bank number, and the amount of the cheque or deposit. The present machine can handle cheques involving values up to 99,999,999·99 dollars.

The keys actuate electrical switches, each of which is connected to five circuits. Four of the circuits establish a code to identify the digit represented by the key—the fifth circuit is for checking purposes. For example, pressing an "8" key closes the first, third and fourth code circuits; the second circuit remains open. Thus, "ERMA" recognises an "8" by circuits 1, 3 and 4 being closed, but 2 being open. This can be represented by 1011. Likewise, number 7 is coded by 1010, and so on. The four circuits provide enough "on-off" combinations to identify all ten digits as well as several symbols. The electronic unit has five input keyboards—four "operators" and a "supervisor." As the machine handles an average account item in half a second, it can switch itself without apparent delay among all operators. Even if all operators press their item-entry bars at once, one of them might have to pause only about a second if she were entering items as fast as possible, before the keyboard would respond to her next entry.

"ERMA" has two magnetic drums, which are part of the temporary information "files" of the machine, capable of servicing a total of 32,000 accounts. The drums are coated with a resin containing small particles of iron oxide, the polarity of which can be controlled under the influence of magnetic fields. Each drum is divided into 300 invisible parallel circular tracks, and each track is divided into sections 0·010in long. Under the influence of electro-magnets mounted close to the drum surface the 1,500,000 magnetic cells on each drum are information storage elements for "bits" (from binary digits) in the binary system. Thus, since five bits are used to identify each number, 300,000 separate numbers may be stored on each drum.

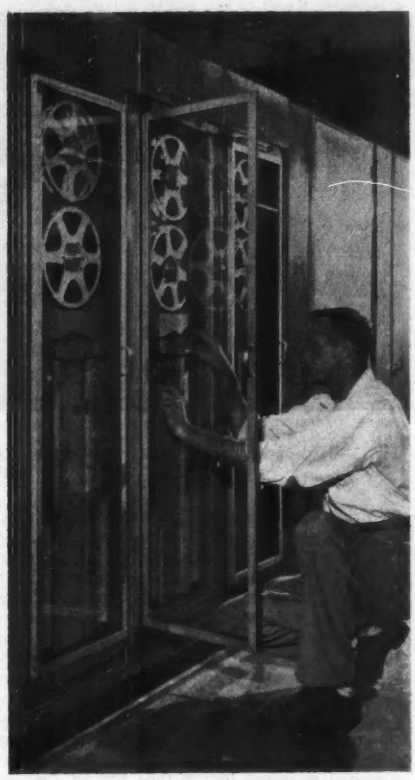


Fig. 2—Part of "ERMA" magnetic tape storage system containing monthly account information

The machine identifies each cheque by "reading" information printed in magnetic ink on the back of the cheque. This code is made up of rows of bars with specific spacing, apparent to the human eye, and is similar to the coding described for the input keyboard. The magnetic ink process allows the machine to read numbers at the rate of 1000 characters a second. "ERMA" is not confused by dirt, ink or other defacements of the coded number. When the cheque passes under a magnetising element in the reader the small iron oxide particles in the bars line up in a prescribed direction. Then the cheque passes under a unit with five magnetic reading heads mounted side by side. Because the positions of the magnet ink bars differ the pattern of voltages at each of the five reading heads differs for each digit. The electronic circuits of the machine are able to distinguish between the resulting unique wave patterns.

The arithmetic unit of "ERMA" is made up of a battery of electronic valves and related components arranged in pairs capable of performing additions and subtractions on sums as large as 99,999,999·99 dollars. Since the "building blocks" of the arithmetic unit can count only up to two, the decimal numbers are represented by specific patterns of binary numbers. The valves arranged in pairs are known as "flip-flops." When a potential is applied to a pair of valves by "ERMA" to "remember" information, one valve becomes conducting, the other non-conducting. Thus, the device essentially stores pieces of information in much the same manner as each cell on the magnetic drum undertakes this same function.

Tape Storage System

More detailed account information is kept on the main information storage system of the machine (Fig. 2). Here it is stored in its incoming sequence, and accounts are maintained in numerical order just as they would be in a filing cabinet. Each of the twelve tape units handles 2400ft of ½in plastic-backed magnetic tape, thereby providing space for the detailed record of all transactions over the period of a month. The tape can be unwound past a set of magnetic heads similar to those used on

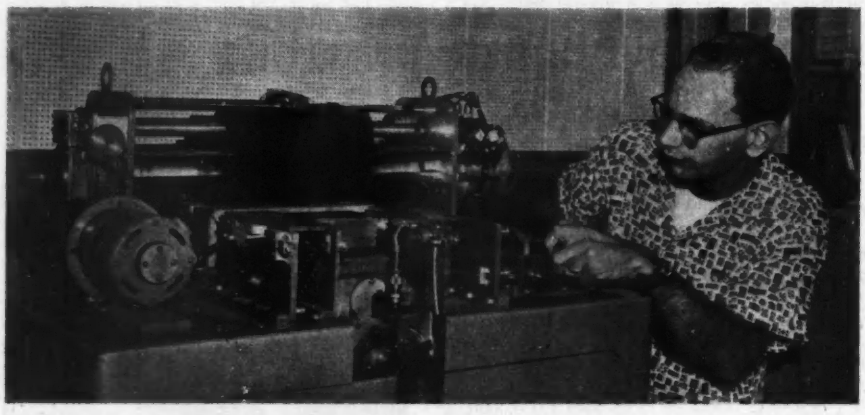


Fig. 3—High-speed printing unit operating at 600 lines per minute for production of monthly account statements

the drum, for "writing" new information on the tape or "reading" information as it is summoned. The tape stores information on the same binary basis—"bits" magnetised either N–S or S–N—as on the magnetic drums. There is room on the standard size of tape for seven information bits in a row across the tape. Because the tape must also store words or letters identifying transactions, seven bits are required to identify all letters and numerals. Thus each row of bits identifies one character. In this way information as to account number, name and address, and account activity for a month can be stored in about 9in of tape for an average banking account. Space on the tape is allocated at the start of each month, based on previous experience with that account. The manner of writing, reading or erasure of information on the tape is essentially as described for the magnetic drum.

Monthly account statements—with service charges automatically calculated—are prepared from information stored on the tape by a high-speed printer. The printer has a continuous speed of 600 lines a minute (Fig. 3) which is soon to be increased to 900 lines and needs human aid only when more paper is required. The commercially available printing element consists of a cylinder with rows of raised characters across it, each row being as wide as the line of printing on the statement. One row contains a succession of A's, the next B's, and so on around the cylinder for the rest of the alphabet, for numerals and other symbols. The cylinder turns continuously at 1200 r.p.m., above a row of stationary striking hammers, one for each character in the row. Between the hammers and cylinder is the statement blank and carbon ribbon.

Fig. 4—Service panel of "ERMA" machine with indicator lights to aid in determining trouble spots in the circuitry

Cheque Sorting

As information from the cheques passes through the bookkeeping functions, the paper (deposit slips and cheques) is sorted for each individual account by an automatic sorter (Fig 5) which "reads" account identifications and sorts cheques at the rate of ten per second. Pneumatic feeding rather than using mechanical friction devices accounts for the efficiency maintained at these high speeds, with errors of less than one in 100,000. To sort cheques, a bundle is placed in the sorter. The top cheques are gripped by a vacuum feeding device and guided to a scanning head set to read the first digit of the account number. This information is momentarily stored on a rotating mechanical memory device. The sorter has twelve compartments (0 to 9 as well as two for rejected cheques) into which it sorts cheques or deposit slips. The cheques are sorted through for each digit separately, requiring the sorting of each bundle five times to place them in proper sequence by account number. After sorting the cheques are filed, to be combined with statements later for forwarding to the customers.

Example of Operation

Mr. Harold Brown writes a cheque for 19.00 dollars to a merchant; his branch number in the Bank of America system is 167 and his account number is 11756. Thus, to "ERMA," Brown is known as 16711756 and his cheques carry this identification in magnetic code. Eventually, the cheque arrives at the desk of one of "ERMA's" five operators via the usual banking channels. It is in one of the thick bundles of cheques against the many accounts for which the machine is responsible. The operator of the input keyboard depresses keys to inform "ERMA" that the 19.00-dollar item is a cheque rather than a deposit. The machine scans Brown's account number and automatically pulls down the keys on his entire identification number—16711756—on the account number section of the keyboard. By pressing an entry bar the operator signals "ERMA" to take over the remaining bookkeeping functions. In an extremely fast chain of events the machine collects the amount and information as to whether the item is a cheque or deposit from the input keyboard and the current balance from the magnetic drum information storage system. It passes these three pieces of information to the arithmetic unit. It also has scanned its drum storage system for two other pertinent bits of information—is there a "stop payment" against this cheque and are there any "holds" against funds in Brown's account? If "holds" are found, their amounts are subtracted from the current balance, or if a stop payment is found the operator is notified.

If sufficient funds remain in Brown's account, the arithmetic unit subtracts the 19.00 dollars from the total. Then a new current balance is established and the machine checks its arithmetic in several ways. The new balance is "written down" on the storage drum, to be held for minutes or perhaps hours until it is convenient for the machine to transfer it automatically to permanent storage on the magnetic tape.

The cheques and deposit slips arrive in a random manner, but obviously must be "filed"

Fig. 5—Automatic cheque sorting machine which reads account identification codes magnetically and sorts cheques at the rate of ten per second

on the tapes in an orderly way. The drum processes information in whatever sequence it arrives and holds it in temporary storage on the drums until it can catch up with its filing on the magnetic tape. A "reading head" automatically searches the tracks on the magnetic drums looking for the next higher account

number for which it has an item to record. That number—assume it is Brown's 11756—and the 19.00 dollar debit are transferred to an intermediate storage register (because the drum operates much faster than the tape) and then to the magnetic tape when the next empty space is found in sequence on the tape. After the item is entered on the tape several cross-checks for accuracy occur. When the machine is satisfied that it has made no error, the action proceeds to the next higher account number for which it holds entries.

The bookkeeping on Brown's 19.00-dollar cheque has now been accomplished and other deposits and withdrawals are entered in a like manner throughout the month. At the close of business each month the tapes are connected to high-speed printers, which convert the coded information into words and numbers for the conventional monthly statement, including service charges automatically calculated, and current balances altered accordingly. Harold Brown's cheques are then machine-sorted, combined with the monthly statement, and returned to him through the mails in the usual manner.

Direct Reading of Arabic Numerals

The present "ERMA" units read binary coded numbers printed on cheques and deposit slips. However, concurrently with the development of "ERMA," a project was undertaken by the Stanford Research Institute to devise a method by which future units could read printed Arabic numerals directly. This study was carried out using the Bank of America's operation involving traveller's cheques, which could be isolated from other phases of banking, but which provides all the elements required for the development of direct number reading by machine. It is expected that this method will be applied to later models of "ERMA."

The numbers printed on the face of the traveller's cheques appear to be ordinary printed numbers. However, they can also be "read" by the scanner with a high degree of accuracy despite disfigurement from overstamping, ink, dirt, fingerprints, or wrinkles. Because the scanner responds only to magnetic ink such obliterations do not confuse it. A magnetic pick-up head somewhat similar to that of an ordinary tape recorder enables the traveller's cheque scanner to identify the Arabic numerals by the specific wave forms produced by each numeral, as shown in the illustration, Fig. 6. As each number—printed in magnetic ink—

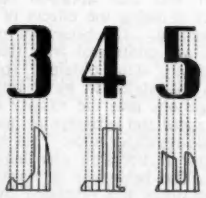


Fig. 6—Representative arabic numerals designed for direct reading

moves laterally across the reading head, the amplitude of the signal will be directly proportional to the amount of magnetic material under the head. Thus, there is a direct relation between the height of each portion of the wave from below and the amount of magnetic ink in the corresponding section of the numeral above.

The machine also verifies its own reading. Each cheque is printed with a nine-digit serial number and a tenth number indicating denomination. In addition, an eleventh number is provided to make the sum of all eleven digits divisible by nine. A computer element in the scanner makes this addition and division after each reading. If the sum is not divisible by nine the scanner "knows" it has not read the number correctly and the cheque is diverted into a separate compartment for manual attention. The prototype scanner reads and verifies eleven-digit numbers at the rate of 100 cheques a minute, and rejects constitute much less than 1 per cent of the total.

Temperature-Sensitive Photographic Device

An interesting instrument, which makes it possible to see in the dark, has been announced by Baird Associates, Incorporated, of Cambridge, Massachusetts. The device, which utilises no electronic circuitry, is called an "evaporograph" and enables one to spot a man 200 yards away or to see a house a mile distant in total darkness. The development of this instrument, which was originally designed for use by the armed services, is based on a principle of infra-red radiation. Different materials radiate varying intensities of infra-red, depending upon temperature and surface; this radiation is present at all times and can be detected from a distance of several miles. In operation, the "evaporograph" is similar to a camera. It collects the radiation emitted from an object and focuses it as an image on to an oil film. The oil then evaporates away from point to point at rates varying with the amount of radiation received at each point. Seen in reflected light, these differences in oil film thickness appear as different colours, like oil films on water. A detailed thermal picture of the field of view is thus obtained in colour. This picture can be viewed directly, or a photographic record can be made with a camera which is incorporated in the apparatus. The "evaporograph" is designed to observe radiation ranging from one to several thousand degrees Fah. and has a sensitivity of about two-tenths of a degree. Thus accurate temperature measurements can be made either visually or photographically from an image.

The instrument is housed in a cabinet 18in by 14in by 11in. The infra-red radiation enters through a lens on one side and the operator views the oil film image through an eyepiece on the other. To date, the firm has built about a dozen of these devices for the military. The "evaporograph" offers a number of new applications in industry and research. Now it is possible to observe simultaneously temperatures over the entire surface of a process vessel or an electronic chassis. Furthermore, it is conceivable that one could inspect the inside of a wireless valve or look at the heat of a flame, and deduce the temperatures in all parts of the scene being viewed. The "evaporograph" also holds promise for the construction industry. A picture of a house in winter, for example, would indicate points where heat was escaping, and where insulation should be added. Medically, the instrument is also interesting. The temperature differences over the surface of the human body are directly related to health. These differences can be seen in detail with the "evaporograph," and the picture so taken has as much detail as a regular photograph. The principle of operation of this instrument was first demonstrated in Germany by Dr. M. Czerny. The work of Baird Associates was originally suggested by Dr. Paul Ovrebo, of the U.S. Air Force, and has been carried on for the past five years, with much of the development being carried out under Signal Corps sponsorship.

Tests of British Navigation System in the U.S.A.

A radio-wave "grid" system that can provide a continuous, all-weather flight-position picture for helicopters, other aircraft, seagoing vessels and mobile ground units, is being tested in south-eastern Arizona. This Decca navigation system was developed in England during World War II and is now in use in an area 1500 miles long across Europe, from Northern Sweden to Spain, giving unbroken navigational coverage and traffic control to the aircraft, the navies and merchant navies of many nations. It uses low-frequency radio signals in contrast to the high-frequency pattern used in conventional American cross-country aircraft navigation. These signals surround a building or mountain as does the atmosphere, and there are no electronic "shadows" or "blind spots." The American rights to the Decca system were obtained in 1954 by the Pacific Division of the Bendix Aviation Corporation, of North Hollywood, California. The division will supply technical assistance to the U.S. Army Signal Corps at tests to be conducted over a period of months at the Army Electronic Proving Ground.

The Bendix-Decca system transmits its low-frequency radio waves as a continuous chain from a main transmitter and its "slave" stations, spaced 70 to 100 miles apart. The radio waves form a precise grid pattern ranging from sea level to extreme altitude, and each chain covers an area of approximately 175,000 square miles. It enables helicopter pilots, for example, to keep a continuous cockpit "motion picture" flight log of their course while flying around sky-scrapers, mountains or other obstacles. An obvious commercial application would be for helicopters ferrying commercial airline passengers to and from airports in such metropolitan centres as Los Angeles, New York and Chicago. The U.S. Army initiated the evaluation tests of the Decca system, and the results of the tests will be used to determine the applicability of the system. Evaluation data also will be made available to commercial industries through the U.S. Department of Commerce.

Baird "evaporograph" being employed to measure heat variations in an electronic chassis of a direct-reading spectograph

Personal and Business

Appointments

MR. EDWARD WARD has been appointed general manager of Diesel Equipment, Ltd., Uxbridge.

MR. SEYMOUR HILLS has been appointed director of studies of the Work Study School at Cranfield, Bedfordshire.

MR. AUSTIN SKROMME has been appointed to the engineering staff of Caterpillar Tractor Company, Ltd., Besford, Leicester.

DR. WOJECH DOMZALSKI has been appointed chief geophysicist of Hunting Geophysics, Ltd., Boreham Wood, Herts.

THE MINISTRY OF SUPPLY has announced the appointment of Mr. C. P. Fogg as head of the ground radar department, Radar Research Establishment, Malvern.

MR. J. W. WATKINS has been appointed a full-time member of the British Transport Commission. At present he is general manager of the London Midland Region of British Railways.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Trafford Park, Manchester, announces the appointment of Mr. N. Thorneley as assistant chief engineer (mechanical), traction projects department.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has announced the appointment of Mr. R. F. Marshall, A.M.I.Mech.E., as manager of the education department, in succession to the late Mr. Kenneth R. Evans.

CANADIAN PACIFIC STEAMSHIPS, Ltd., Liverpool, has announced the following appointments: Mr. E. O. Wilkinson, assistant chief superintendent engineer; Mr. R. Y. Pritchard, assistant naval architect, and Mr. F. W. Evans, electrical superintendent.

CLIFFORD CULTIVATORS, Ltd., Hall Green, Birmingham, states that Mr. Jack Benger has been appointed to take responsibility for field sales promotion. Mr. L. Tedd has succeeded him as technical representative in the Midlands and North West, and Mr. K. Shephard has been appointed technical representative for the South West.

FORD MOTOR COMPANY, Ltd., Dagenham, states that Mr. L. Childs has been appointed manager of blast-furnace and coke-oven operations. He succeeds Mr. F. Pearson, who has reached retiring age. Mr. Pearson will continue for a period to assist in the development of projects concerned with the company's blast-furnace and coke-oven facilities.

MR. EDWARD POWELL has been appointed general sales manager of the Chloride Electrical group, and Mr. A. C. Stewart has been appointed sales manager of Chloride Batteries, Ltd. These appointments follow the retirement of Mr. H. V. Schofield from active duties as sales director of Chloride Electrical Storage Company, Ltd. Mr. Schofield will continue to serve on the board.

Business Announcements

PEGSON, Ltd., Coalville, states that its telephone number has been changed to Coalville 1234.

THE COSELEY ENGINEERING COMPANY, Ltd., has moved its London office to 41–46, Piccadilly, W.1 (telephone, Regent 4924).

SPENCER-BONECOURT, Ltd., is moving on June 18th to Lynton House, 7–12, Tavistock Square, London, W.C.1 (telephone, Euston 4321).

MIDLAND SILICONES, Ltd., has moved its Birmingham branch office to Union Chambers, 63, Temple Row, Birmingham, 2 (telephone, Midland 7705).

THE AIR SURVEYS COMPANY, Ltd., states that it is incorporating the name of the parent company in its title and will be known in future as Fairey Air Surveys, Ltd.

SMART AND BROWN (MACHINE TOOLS), Ltd., has acquired control of Pultra, Ltd. The registered office of the latter company has been moved to 24, Manchester Square, London, W.1.

THE BRITISH TABULATING MACHINE COMPANY, Ltd., states that it has made arrangements with Laboratory for Electronics, Inc., Boston, U.S.A., for the joint establishment at Boston of a research and development company for the immediate purpose of completing the design and development of a computer of particular interest in the business machine field. The first of such machines is due for delivery to the Chase Manhattan Bank of New York next year, and the second will be delivered to the British Tabulating Machine Company, Ltd., immediately afterwards. The name of the new company is International Computers Corporation Inc.

Contracts

BIRLEC, Ltd., Birmingham, has received a contract from Wellworthy, Ltd., Lymington, Hants, for a high-frequency melting furnace installation. It comprises one 1250kW motor alternator set and two furnaces each of 3 tons capacity.

THE MINISTER OF TRANSPORT AND CIVIL AVIATION, Mr. Harold Watkinson, on the advice of Frederick S. Snow and Partners, the Ministry's Consulting Engineers for Gatwick Airport, has awarded the contract for the construction of the runway, taxi-tracks, hardstandings, drainage and ancillary civil engineering works at Gatwick to Sir Alfred McAlpine and Son, Ltd., Little Sutton, Wirral, Cheshire.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has received a contract for two further steam turbine-generator sets, each rated at 30MW, from the China Light and Power Company. They will be installed in the Hok Un generating station on the mainland of Hong Kong. The contract, which is worth nearly £700,000, includes the associated condensing, feed heating and evaporating plant. The new sets are to be delivered during 1958.

THE ENGLISH ELECTRIC COMPANY, Ltd., has received an order from the Crown Agents for Overseas Governments to supply and erect two 10,000kW steam turbo-alternator sets for the Malayan Central Electricity Board. The value of this order is approximately £350,000. These two sets will be installed in a new generating station which is to be built at Malacca on the West Coast of Malaya. The consulting engineers for the project are Messrs. Preece Cardew and Rider.

SOUTH DURHAM STEEL AND IRON COMPANY, Ltd., Stockton-on-Tees, has received a contract from the Trans-Canada Pipe Line Company for the supply of 636 miles of 30in diameter steel pipe for the construction of the centre section of the trans-Canada pipe line from Winnipeg in the west to North Bay in eastern Ontario. At the present level of prices the value of this contract exceeds 32 million dollars; deliveries are to begin in April, 1957, and are to be completed by July, 1959.

KINGSTON (ARCHITECTURAL CRAFTSMEN), Ltd., has received an order for the design and manufacture of eight laminated timber arches and four half-arches, having a span of 75ft, with a ridge height of 33ft 6in. Messrs. Firth, Son and Blackburn are the architects, and the arches will be used for a new dyehouse for The Birstall Carpet Company, Ltd., Birstall, Yorkshire. The arches will, it is thought, be the largest of their kind; they were specified in the belief that timber would withstand the decay hazards of the manufacturing processes which it will house better than either steel or concrete.

THE GENERAL ELECTRIC COMPANY, Ltd., has received a further order from the British Transport Commission for power equipments for British Railways' standard 350 h.p. diesel-electric shunting locomotives. The forty-five equipments now ordered will be similar to the fifteen already supplied, all of which are in service in the North Eastern Region of British Railways. The power unit consists of a Lister-Blackstone E.R. (Traction) four-stroke, vertical, six-cylinder engine direct-coupled to a G.E.C. single-bearing main generator, on top of which are mounted an auxiliary generator and traction motor blower.

Miscellanea

DRY STONE WALLING.—At the forthcoming show of the Royal Agricultural Society, at Newcastle upon Tyne, there is to be a dry stone walling competition, open to entrants from Great Britain. Competitors will be required to build 2 yards of wall, 4ft 6in high, in four hours, using local freestone.

NYLON CENTRIFUGE TUBES.—Lacrinoid Products, Ltd., is now supplying transparent nylon centrifuge tubes which will run up to 20,000 r.p.m. on an angle rotor. This allows fine colloidal solutions, for example, to be subjected to gravity fields up to 45,000*g*. Cellulose acetate tubes have been found to distort permanently at this speed, while glass tubes tend to fail at 6000 r.p.m.

DITCH CLEANING MACHINES.—The Royal Agricultural Society of England is offering silver and bronze medals for mechanically-operated appliances, judged most suitable for cleaning farm ditches, with a top width of 4ft or less, that are accessible from only one side. Suitability for cleaning other kinds of ditch may be taken into consideration. Self-contained machines and tractor attachments, whether in manufacture or contrived by farmers for their own use, are equally eligible. Each competitor must demonstrate his appliance to the judges, on a site chosen by himself, at some time approved by the Society, between September 1st and December 31st next. A second demonstration, on a site selected by the Society, may also be required between February 1 and April 30, 1957. The winning machines will be exhibited at the 1957 Royal Show at Norwich. Provisional entries for the competition must reach the Society not later than August 1st next.

OBITUARY.—We record with regret the death of Mr. W. N. Duffy, which occurred suddenly on May 24th, at Torquay, where he was attending the British Electrical Power Convention. Mr. Duffy, who was fifty-seven, joined Ferranti, Ltd., in 1932, as chief industrial artist, and had been the firm's publicity manager since 1951. We have also learned with regret of the death, through a motor accident on May 22nd, of Mr. Charles George Carrothers, M.I.Mech.E., M.I.E.E. Mr. Carrothers, who was sixty-four, was the senior engineer and head of the research department of Kennedy and Donkin, consultants, of Westminster.

CORE AND MOULD MAKING BY THE CO_2 PROCESS.—The Association of Bronze and Brass Founders has just published a report entitled "A Survey of the CO_2 Process for Core and Mould Making," which will be of particular interest to all foundries in view of the profound impression that this process has already made on the industry. The report follows a survey in which fifteen foundries were visited and discussions were held with the principal suppliers of both the binder and the gas used in the process. The main sections of the report deal with the principles and background of the process; metals cast and materials used; preparation and properties of CO_2 process mixes; the gas and its application; patterns and core boxes used for the process; mould and core production; contamination and reclamation of sand, and the economies of the process. Copies of the report can be obtained from the Association's offices, 69, Harborne Road, Edgbaston, Birmingham, 15, price 5s. each.

COMPARATIVE PROPERTIES OF RUBBERS.—A one-day conference, on May 11, organised by the London Section of the Institution of the Rubber Industry, was devoted to the "Comparative Properties of Vulcanised Rubbers." In opening the conference, the chairman, Mr. H. C. Baker, explained the difficulty in selecting a title and emphasised that non-vulcanisable materials in their final form would be included in the scope. It was inevitable that some consideration would also have to be given to the conditions of testing. In the opening paper, Mr. L. Mullins discussed the shortcomings of laboratory tests for tear and abrasion resistance and presented data showing the effects of temperature and rate of tearing. The behaviour of GR-S and butyl rubbers was contrasted with that of natural rubber. Arbitrary data obtained from standard abrasion tests was stated to be of little value and recent investigations into the relative contributions of roughness, speed and temperature had provided a clue to their relative importance. That tearing was an important factor in abrasion was demonstrated by comparisons. The behaviour of various polymers at high temperatures was discussed by Mr. E. G. Williams, who emphasised the long-term effects resulting from simultaneous oxidative degradation and continued vulcanisation. Studies of how the properties change with temperature showed that the temperature coefficient of ageing was dependent on the property measured and on degree of ageing chosen. Mr. R. H. Norman dealt with the chief electrical properties of a range of rubbers and P.V.C., showing that these properties depended largely upon the degree of purity of polymer used, extent of oxidation and temperature of test. The relationship between chemical type of polymer and dielectric loss in the vulcanisate was discussed and some data on anti-static rubbers given. Mr. S. E. Bolam classified and compared the many kinds of polymer dispersion or latex now available in this country, indicating the major features of each type of vulcanisable elastomer: GR-S for low cost, neoprenes for flame and oil-resistance, nitriles for solvent resistance and compatibility with vinyl and phenolic resins. The non-vulcanisable dispersons give low strength products but are useful as films and finishes. The concluding paper dealt with Neoprene and Hypalon. Hypalon is outstanding in resistance to ozone, high temperatures and corrosive chemicals. Neoprenes also possess high stability to many such influences. In a comparison of these two types Mr. J. F. E. Ruffell forecast a big future for them because of their all-round excellence as compared with other elastomers.

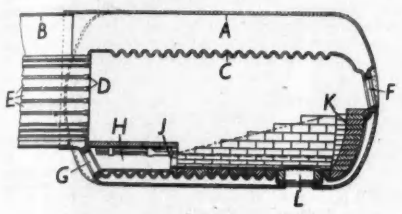
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

STEAM GENERATORS

748,896. May 4, 1953.—LOCOMOTIVE TYPE BOILERS, William Charles Ikeson, Southview Drive, South Woodford, London, E.18.

The invention relates to improved locomotive type boilers. As shown in the drawing, a cylindrical boiler shell *A* with dished ends has fitted to it eccentrically at one end a cylindrical boiler barrel *B* and contains a combustion chamber consisting of a cylindrical, corrugated furnace-tube *C* which at one end has a flat tube plate *D* from which the smoke tubes *E* extend through the barrel *B*, and at the other end a dished backplate with a firehole *F*. Passing through the crescent-shaped lower part of the end wall of the shell *A* and through the end wall of the com-



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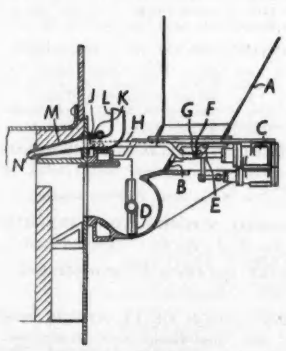
bustion chamber, is an air passage *G* which extends to an air tube *H* within the combustion chamber *C* and contains the liquid fuel burner *J*. A flash wall *K* of firebricks is provided at the other end of the combustion chamber to ignite the fuel ejected by the burner and to protect the furnace-tube *C* and backplate from the direct flame. An air hopper *L* in the base of the chamber aids combustion. The firebrick-insulated tube *H* brings the burner within the required distance of the flash wall, provides the main air inlet and preheats the incoming air. The arrangement of firing from the tube-plate end of the furnace with the action of the induced draught forces the flame to turn upwards and the hot gases to bend round and travel in the opposite direction in order to reach the vicinity of the tube-plate. This delayed action brought about by the reversal of direction of flow enables complete combustion of the fuel to take place within the furnace before reaching the smoke tubes. The correct amount of air for combustion is controlled by dampers fitted to the air tube *H*, the air hopper and the firehole *F*, and a uniform temperature can be maintained throughout the furnace in relation to the amount of fuel consumed. —*May* 16, 1956.

749,090. September 7, 1953.—BOILER STOKING INSTALLATIONS, J. and J. Neil (Temple), Ltd., Temple Park Iron Works, Glasgow, Scotland. (*Inventors: John Macbean Neil and James Welsh.*)

The invention relates to a boiler stoking installation of the sprinkler type, in which solid fuel is thrown into the boiler furnace. It's object is to provide improved means for admitting to the furnace at least a portion of the secondary air necessary for efficient combustion of the fuel. In the drawing *A* is a hopper and *B* a pusher coupled to the piston of a hydraulic cylinder *C*, the stroke of the pusher being



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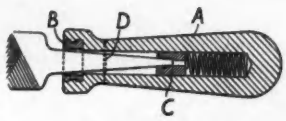
variable. *D* is a rotary fuel impeller. The plunger of the hydraulic cylinder *C* is coupled to a swing link *E* with a radial slot *F* in which is movable a pin *G* attached to one end of a connecting rod *H*, the other end of which is pivoted to a crank *J* coupled to a flap valve *K* in an air duct *L* leading to a nozzle *M*, the orifice *N* of the nozzle being so positioned that the path of discharge of air from the orifice is obliquely downwards across the path of discharge of fuel from the impeller *D*. The pin *G* can be clamped in a predetermined position in the slot *E*. In practice, fuel from the hopper *A* falls and is pushed towards the impeller which injects it into the furnace, the injection into the furnace taking place during each forward stroke of the pusher. The quantity of fuel injected in a given time is determined by the length of stroke of the pusher. While the pusher is moving forward, the swing link *E* is swinging away from the hydraulic cylinder *C*, the connecting rod *H* being also moved with the swing link *E* in the direction to open the flap valve *K*. Air from the duct *L* is thus discharged through the nozzle *M* and the orifice *N* at the same time as fuel is injected, the blast providing secondary air for combustion of the injected fuel and at the same time deflecting the lighter particles of fuel downwards so that the front portion of the furnace is not starved of fuel. Dust and lighter particles injected into the furnace are blown on to the bed of burning fuel, where they are consumed. The position of the pin *G* in the slot *F* is so arranged that the flap valve *K* opens to the required extent to admit the correct quantity of secondary air for combustion of the particular grade of fuel. During the backward stroke of the pusher *B* the flap valve *K* is closed so that no secondary air is admitted while no injection of fuel is taking place. The correct quantity of air for combustion of the fuel is thus always admitted.—*May* 16, 1956.

TOOLS AND WORKSHOP APPLIANCES

748,658. July 22, 1953.—HANDLES FOR HAND TOOLS, John Baker, formerly of 195, Wentworth Road, Doncaster, but now of "Three Chimneys," Bawtry Road, Bessacarr, Doncaster.

As shown in the drawing, the tool handle comprises a moulded body *A* of round cross section, rounded at its rear end and tapering towards its front end, where it is enlarged and provided with a



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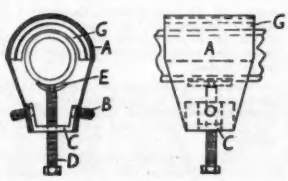
die-nut *B* as a moulded-in insert. The handle bore is closed by the integral rear end of the handle, the bore being substantially of the same diameter as the thread diameter of the die-nut. Sliding in the bore is a tang-receiving bush *C* backed by a coil spring which bears against the closed end of the bore. Set in the handle between the bush and the die-nut is a pin *D* which prevents withdrawal of the bush from the bore. The opening in the bush is tapered to receive the end of the tool so as to centrally locate the tang as it is being rotated in the die-nut *D*. The retaining pin is located clear of the tang.—*May* 9, 1956.

749,155. March 17, 1954, DEVICES FOR REPAIRING FRACTURES IN PIPES, Hubert Charles Griffin, 14, Goldhawk Road, London, W.12.

The invention provides a first aid repair for burst or leaking water and gas pipes. As shown in the drawing, there is provided a flexible metal band *A*, the middle contour of which is formed to a radius, the ends being tapered down and having holes to receive studs *B* fixed in the bent up sides of the bridge



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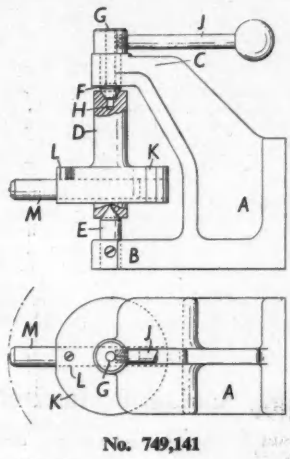
piece *C*. The band and bridge piece can pivot independently. An adjusting screw *D* is screwed into the base of the bridge piece and through the medium of a pivoted pad *E* on the inner end of the screw *D* will pull the pads *G* firmly on to the fractured pipe. On the larger pipes only one rubber pad is required. It will be seen that either one or both ends of the band can be released for assembly on the pipe. A modified construction is also shown in the specification. Features of the invention are the pivoting of the band on studs in the bridge piece and provision for adjustment of the band ends to a greater range of pipe diameters and also to bends or distortion of the pipes.—*May* 16, 1956.

MACHINE TOOLS

749,141. January 8, 1954.—TOOL HOLDERS, Engineering Diamonds, Ltd., 26, Warwick Row, Coventry, and Reginald Allen, 51, The Scotchill, Keresley, Coventry.

The invention relates to tool holders for use on machine tools. As will be seen from the drawing, the tool holder comprises a base *A* having a pair of vertically spaced arms *B* and *C* between which a mandrel *D* is rotatably supported by centre pins *E* and *F* supported in the arms. The lower centre pin *E* is removably supported in an aperture extending through the lower arm of the base and is



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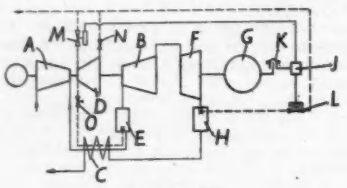
secured by a screw. The upper centre pin *F* is fixed and is provided with a bore in which is rotatably supported a spindle *G*. The lower end of the spindle extends beyond the centre pin and is of square cross section to engage in a recess *H* in the mandrel so that it can be rotated. The upper end of the spindle extends above the arm to receive a collar with an operating handle *J*. The mandrel *D* has an annular flange portion *K* through which extends a bore *L* adapted to receive the shank *M* of a cutting tool secured by a screw. Thus, upon rotation of the mandrel *D* by the handle, the cutting point of the tool is caused to move along a circular path concentric with the axis of the mandrel.—*May* 16, 1956.

GAS TURBINES

749,263. July 20, 1953.—A GAS TURBINE INSTALLATION WITH AN AFTER-BURNING CHAMBER, Maschinefabrik Augsburg-Nurnberg A.G., Stadtbach Str. 7 (13b), Augsburg, 2, Germany.

The invention relates to a gas turbine installation with internal combustion, in which the sensible heat still contained in the exhaust gases is transferred to the compressed combustion air by means of a heat exchanger connected to the discharge side of the turbine. In the drawing a compressor *A*, connected to a turbine *B* sucks in air from the free atmosphere and compresses the air to the required working pressure. The compressed air is afterwards preheated in a heat exchanger *C*, through which exchanger the exhaust gases of the turbine are arranged to flow. Coaxially with the turbine *B* there is a second compressor *D*, in which fuel gas is compressed up to the pressure in the main combustion chamber *E*. The compressed fuel gas is burnt in the main combustion chamber in the presence of a considerable surplus of air. The hot combustion gases flow to gas turbines *B* and *F*. The low-pressure turbine *F* drives an electric generator *G*. In the exhaust duct between the turbine *F* and the heat exchanger *C* there is an auxiliary or after-burning chamber *H*, which is operated for short periods for the purposes of regulation. Fuel is introduced to the chamber and burnt in it, whereby the temperature of the turbine exhaust gases is subsequently and rapidly increased. Should the loading of the generator *G*, and consequently of the gas turbine *F*, be increased, the auxiliary or after-burning chamber *H* is automatically brought into operation as a result of a regulating member *J*, which is directly dependent on a governor *K* and opens a valve *L*. The temperature on the input side of tne turbine *B* increases. Extra power is created which results in acceleration of the compressor set *D*, so that more air and gas is compressed and more useful power is generated. When the new operating point is reached the valve *L* is shut again, while the temperature increase produced on the input side of the turbine *B* by the operation of the auxiliary combustion chamber *H* and acceleration

ceases. If a decrease in output occurs, the controlling member *J* opens an overflow valve *M*, with the result that the combustion chamber *E* receives less combustion gas. When the installation is started up, valves *N* and *O* are closed and the valve *M* is opened, so that the fuel gas compressor merely runs in a vacuum. The necessary heat is generated only



No. 749,263

in the after-burning chamber *H*. The compressor *D* is only brought into operation by hydraulic means when the installation is loaded. Finally, there can be seen in the drawing a starter motor *P* employed to start the gas turbine installation. The proposed method of regulation is obviously not limited to the arrangement mentioned. Thus the compressors *A* and *D* may also be driven by the low-pressure turbine, the useful output being derived from a high-pressure turbine. In peak-load installations all the machines may be mounted on one shaft, the turbines *B* and *E* being combined into a single unit. Finally, the compression can also be effected in a plurality of air and gas compressors connected in series and driven by a plurality of turbines.—*May* 23, 1956.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

LEAD PIPES FOR OTHER THAN CHEMICAL PURPOSES : LEAD PIPES FOR OTHER THAN CHEMICAL PURPOSES (SILVER-COPPER-LEAD ALLOY)

No. 602 : 1956 and No. 1085 : 1956. Price 6s. The revised editions of these two standards have been included under one cover, as pipes complying with both standards mainly serve the same applications for other than chemical purposes, and they are made by the same extrusion presses.

In the revised B.S. 602 the existing two compositions are retained, but with some amendment, and a third composition has been added. For some applications lighter weight pipes are permitted, and this has necessitated the introduction of additional tables, as the heavier weight pipes are still recommended for service underground. In the revised B.S. 1085 a slight amendment has been made to the composition and additional tables have been included to permit the use of lighter weight pipes for certain applications.

The tables in both standards specify the minimum weight to be used for each application. When sizes above the minimum are required, the new standard specifies that they should be chosen from the list of standard bores and weights given in an appendix in order to limit the number of sizes of pipes demanded.

OUTLINE DIMENSIONS FOR ELECTRIC LIFTS

No. 2655, Pt. 3 : 1955. Price 3s. This new standard gives outline dimensions for the installation of six classes of electric lifts : light traffic passenger lifts, general-purpose passenger lifts, intensive traffic passenger lifts, hospital bed/passenger lifts, general duty goods lifts, and heavy duty goods lifts. In it dimensions are given for the lift well, entrances, sills and machine room floor in relation to the car floor, the car's capacity and its speed.

Parts 1 and 2 of this standard, now in course of preparation, are concerned with the constructional and safety requirements for electric lifts and with lift motors respectively. The proposed drafts of the documents will be circulated to industry and interested organisations in accordance with the usual procedure of the B.S.I., and comments received will be taken into account when the final standards are prepared for publication.

P.V.C. INSULATED CABLES AND FLEXIBLE CORDS FOR ELECTRIC POWER AND LIGHTING

No. 2004 : 1955. Price 6s.—This revision of B.S. 2004 has been published to incorporate an amendment providing for tinned copper conductors, with plain copper conductors as an alternative, to be supplied when specified by the purchaser. It covers working voltages up to 250V. Apart from changes resulting from the introduction of tinned conductors, such as the inclusion of a tinning test, and a few corrections and minor editorial amendments, the text is the same as that of the 1953 edition.

Launches and Trial Trips

HARVELLA, oil tanker ; built at Belfast by Harland and Wolff, Ltd., for Shell Tankers, Ltd. ; length between perpendiculars 530ft, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,000 tons ; thirty-three cargo oil compartments, one main cargo pump room, two 550kW, 60 c/s turbo-alternators, one 200kW diesel-driven auxiliary alternator ; one set of double reduction geared turbines ; 7500 s.h.p. two Babcock and Wilcox water-tube boilers supply steam at 500 lb per square inch and 800 deg. Fah.—Launch, April 26th.

MICHAEL G. LIVANOS, cargo ship ; built by the Burntisland Shipbuilding Company, Ltd., for Formentador Compania Naviera S.A. Panama ; length between perpendiculars 435ft, breadth moulded 59ft 9½in, depth moulded to upper deck 39ft 6in, deadweight 11,850 tons ; five holds, one 30-ton and ten 10-ton derricks, electric deck machinery ; three 150kW diesel-driven generators, one 35kW generator for port use ; Kincaid-B. and W. two-stroke, single-acting diesel engine, seven cylinders, 620mm diameter by 1870mm combined stroke, 5500 b.h.p. at 120 r.p.m.—Trial, April.

AMALTHEE, cargo ship ; built by the Chantiers Dubigeon for the Societe Navale Caennaise ; length overall 259ft 2¼in, length between perpendiculars 236ft 3in, breadth moulded 40ft, depth to shelter deck 22ft, draught 14ft 9in, deadweight 1200 tons, trial speed 15 knots ; one Sulzer mark 6S.D.60 single-acting, two-stroke diesel engine, built by the Chantiers de l'Atlantique (Penhoet-Loire), 3000 h.p. at 150 r.p.m.—Trial, April.

Catalogues and Brochures

EXPANDITE, Ltd., Chase Road, London, N.W.10.—Leaflet dealing with "Expandite" machines giving details of their uses for joint sealing and maintenance of concrete pavements.

RADIO HEATERS, Ltd., Eastheath Avenue, Wokingham, Berks.—Pamphlet dealing with "Radyne" H/6A plastic preheater used for plastic moulding with loads up to 1 lb or 2 lb (450 gr. or 900 gr.).

ALFRED BULLOWS AND SONS, Ltd., Long Street, Walsall, Staffs.—Folder giving details of modifications of the "L.20" air motor with its arrangement of mounting when used for ceramics or other highly abrasive materials.

BRITISH BITUMEN EMULSIONS, Ltd., Dundee Road, Trading Estate, Slough, Bucks.—Pamphlet giving details of "Wearproof," a method of reconditioning concrete floors in factories or warehouses.

BURTON, GRIFFITHS AND CO., Ltd., P.O. Box 232, Montgomery Street, Sparkbrook, Birmingham, 11.—Brochure dealing with "BSA" screwed shank tools, giving details and price lists covering this range of tools.

R. AND J. DICK, Ltd., Greenhead Works, Glasgow, S.E., Scotland.—Descriptive catalogue giving details of "Dickrope-plus V-rope" drives, dealing with construction and a method of calculating drives by the "Andix" system.

THE BENJAMIN ELECTRIC, Ltd., Brantwood Road, Tottenham, N.17.—Descriptive folder containing lighting specification, giving the planning, general layout and individual lighting, compiled by "Benjamin" illuminating engineering service.

W. C. HOLMES AND CO., Ltd., P.O. Box B7, Turnbridge, Huddersfield.—Publication No. 60, entitled "Gas Condensing and Cooling," giving details of condensing and washing, principles of design, secondary cooling and design and dimensions of coolers.

SQUARE, D., Ltd., 100, Aldersgate Street, London, E.C.1.—Catalogue illustrating a range of control gear, i.e. multi-pole relays, motor starters, push button units, limit and pressure switches, timing relays, thermal overload relays and voltage testers, &c.

SIMON-CARVES, Ltd., Cheadle Heath, Stockport.—Illustrated catalogue entitled "Modern Coke Ovens," giving an outline of the latest Simon-Carves practice in coke oven design, also with a brief desciption of some of the major coke ovens contracts received by the firm.

CARTER GEARS, Ltd., Thornbury Road, Bradford, 3, Yorkshire.—Technical booklet dealing with "F" type "Carter" hydraulic infinitely variable speed gears used for small power variable speed drives and using reduction units they are capable of low-speed, high-torque duties.

A. E. CAWKELL, 6-8, Victory Arcade, The Broadway, Southall, Middlesex.—Leaflet describing noise and vibration measuring equipment, type "NMP," continuously variable band-pass filter, type "FU (Mk. 2)" and sound level meter, type "SLM G" meter.

FIRTH BROWN TOOLS, Ltd., Speedicut Works, Carlisle Street East (P.O. Box No. 59), Sheffield, 4.—This catalogue includes all the products manufactured by the firm and deals with its extensive range of engineers' cutting tools, woodworking tools, as well as certain of its small machine tools.

THE R.J.H. TOOL AND EQUIPMENT COMPANY, Ltd., Artillery Street, Heckmondwike, Yorkshire.—Brochure illustrating and describing fully each of a range of grinding and polishing machines, also ancillary products, such as dust exhaust equipment, contact wheels, abrasive bonds, surface plates, &c.

FLETCHER MILLER, Ltd., Alma Mills, Hyde, Cheshire.—Sixty-four-page brochure reviewing cutting fluids, oils and coolants for use in the machine shop. The book is arranged in nine main sections, giving details of the cutting fluids available, the work they do and their general characteristics. Photographs illustrate many typical applications.

POWER AUXILIARIES, Ltd., Kembrey Street, Swindon, Wilts.—Illustrated brochure describing "Plessiflex" seamless, flexible metal hose. The hose is used for conveying liquids or gases at high pressures between junctions which may expand, contract, vibrate, move angularly, or be exposed to high temperatures. The range of sizes available for production is from ¼in to 2in bore.

CARTER GEARS, Ltd., Bradford, 3, Yorkshire.—Technical booklet No. F/3, describing type "F" hydraulic infinitely variable speed gears. Sizes F10, F12 and F14 rated at 0·625 h.p., 1·25 h.p. and 3·0 h.p. respectively are covered, together with details of gears fitted with flange-mounted spur reduction gears for low-speed conditions. Installation and maintenance instructions are included.

HENRY MEADOWS, Ltd., Fallings Park Wolverhampton.—Brochure covering a range of diesel, petrol and natural gas engines suitable for applications where motive power is required between 15 b.h.p. and 270 b.h.p. Examples of these applications are given under four main groups, "Industrial, Stationary," "Automotive and Railcar," "Marine," and "Gearboxes." A general review of the firm's activities is also included.

BAKELITE, Ltd., 12-18, Grosvenor Gardens, London, S.W.1.—Booklet describing the production from polyester resins and glass fibre of such structures as boat hulls, caravan bodies, motor car bodies and commercial vehicle components. The process, which can be varied to suit individual requirements, consists essentially of impregnating glass fibre reinforcement with resin and allowing it to harden in a suitable mould. Also a revised book of technical data sheets on polyester resins.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, June 8th.—BRISTOL AND WEST OF ENGLAND BRANCH : Grand Hotel, Annual General Meeting, 7.30 p.m.

Mon., June 11th.—CENTRAL LONDON BRANCH : St. Ermins Hotel, Caxton Street, London, S.W.1, Annual General Meeting, 6.15 p.m.——N.W. LONDON BRANCH : Century Hotel, Forty Avenue, Wembley Park, Annual General Meeting, 7.30 p.m.

Tues., June 12th.—BOURNEMOUTH BRANCH : Grand Hotel, Firvale Road, Bournemouth, Joint Meeting and Discussion with Electrical Association for Women, 7.15 p.m.——LUTON BRANCH : Midland Hotel, Williamson Street, Luton, Annual General Meeting, Conference Report and Election of Officers, 7.30 p.m.——W. LONDON BRANCH : Windsor Castle Hotel, 134, King Street, Hammersmith, Annual General Meeting, 7 p.m.

Wed., June 13th.—Chamber of Commerce, New Street, Birmingham, Annual General Meeting, 6.30 p.m.——HALIFAX BRANCH: Crown Hotel, Horton Street, Halifax, Annual General Meeting and Election of Officers, 7.30 p.m.——S.W. LONDON BRANCH : Guild House, 32, Worple Road, Wimbledon, Annual General Meeting, 7.15 p.m.——YORK BRANCH : Shambles Cafe, York, Annual General Meeting, 7.15 p.m.

Sat., June 16th.—OXFORD, READING AND DISTRICTS BRANCH : Y.M.C.A., 10, George Street, Oxford, Annual General Meeting, 7 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Wed., June 27th.—Management House, 8, Hill Street, London, W.1, "The Automatic Factory—Its Evolution and Implications," J. F. Coales, 7 p.m.

INCORPORATED PLANT ENGINEERS

Tues., June 12th.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "Small Industrial Water-Tube Boilers," G. H. Steward, 7.15 p.m.

Thurs., June 14th.—MERSEYSIDE AND N. WALES BRANCH : Royal Institution, Colquitt Street, Liverpool, Brains Trust on "Fuel and the Future," 7.15 p.m.

Fri., June 29th.—BIRMINGHAM BRANCH : Imperial Hotel, Birmingham, "Spring Design and the Plant Engineer," A. A. D. Brown, 7.30 p.m.

INSTITUTE OF METALS

Wed., June 13th.—METAL PHYSICS COMMITTEE : Weir Hall, Institution of Naval Architects, 10, Upper Belgrave Street, London, S.W.1, "Some Recent Studies of Irradiation Effects in Metals and Other Solids," R. Smoluchowski, 6.30 p.m.

INSTITUTE OF NAVIGATION

Wed., June 20th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Crossing Antarctica," George Lowe, 5 p.m.

INSTITUTE OF PETROLEUM

To-day and Sat., June 8th and 9th.—SUMMER MEETING : Palace Hotel, Torquay, "Essential Factors in the Future Development of the Oil Industry."

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., June 14th.—LONDON CENTRE : All-day visit to the works of Simms Motor Units, Ltd., East Finchley, London, N.2.

INSTITUTION OF CIVIL ENGINEERS

Mon. to Fri., June 18th to 22nd.—Great George Street, Westminster, London, S.W.1, Colonial Engineering Conference, Monday at 3 p.m. and following days at 10 a.m.

Wed., June 20th.—Great George Street, Westminster, London, S.W.1, Conversazione, 7.45 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Thurs., June 21st.—Royal Festival Hall, London, S.E.1, Conversazione, 7.45 p.m.

Mon. to Fri., June 25th to 29th.—Summer Meeting.

INTERNATIONAL MACHINE TOOL EXHIBITION, 1956

Fri. to Fri., June 22nd to July 6th.—Olympia, London.

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Tues., June 12th.—Summer Meeting.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., June 18th.—Great George Street, Westminster, London, S.W.1, "Research and the Rural Landowner," His Grace the Duke of Northumberland, 2.15 p.m.

SCIENTIFIC INSTRUMENT MANUFACTURERS' ASSOCIATION

To-day, June 8th.—ELECTRONICS SECTION : Royal West of England Academy, Bristol, Exhibition, "Atoms, Electrons and Industry."